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ATOMIC WEAPONS AND THE KOREAN WAR

AT THIS writing, the consequences of the communist invasion of the Korean republic and of the U.N.-sanctioned intervention in defense of this republic, cannot be foreseen. Hope is not yet lost that in the face of American determination to resist, the Soviet leaders will decide to call the invasion off and order the communist troops to retire behind the 38th parallel. They operate on a long-time schedule, and can afford losing "face" much better than countries with a vocal public opinion.

It is much more likely, however, that the communists will do all in their power to prolong the Korean conflict—without spreading it—hoping to make this campaign as unprofitable, as disappointing, and as undermining for American prestige in the East, as the Indo-China war proved to be for France.

Finally, it is not impossible—although not very probable—that, either in accordance with Soviet plans, or despite them, the Korean conflict will not remain localized for long, but similar situations will erupt over all Southeast Asia, if not the whole world.

* * *

Whatever the development in the next few months, one fact has already been demonstrated by the first weeks of Korean fighting: It is the utter uselessness of atomic weapons in the present stage of our power contest with the Soviet Union—a stage which is intermediate between the "cold" war of the past three years and the threatening all-out "hot" war. (It could, perhaps, be called "warm" war.) It is not unlikely that this period will witness a series of "small wars" waged by the communist satellites or guerilla armies in Asia and Europe while the Soviet Union will remain formally at peace with everybody, proclaiming strict adherence to the principle of non-intervention.

A lone conservative member of the British Parliament has suggested that the way to finish the Korean war in a hurry is to drop an atomic bomb on the capital of Northern Korea. This suggestion is obviously absurd. Flattening the capital of Northern Korea with or without killing tens of thousands of its inhabitants would not destroy the fighting capacity of the communist army; but it would immeasurably strengthen their case in the eyes of the world, and weaken the cause for which America is fighting. Having destroyed the cities of communist-led Northern Korea, would the next step be to destroy communist-occupied Seoul, the capital of the South Korean republic, whose freedom and independence we are defending? It is hardly necessary to add that the possession of hydrogen bombs, for which we are striving, would have been of no help at all in this predicament.

* * *

Essentially the same situation would confront us if war were to involve communist China—as well it may—or any other satellite nations in the East or in the West. Defending Indo-China against Chinese communists, or the Philippine republic against communist-led rebels, or supporting Jugoslavia against an attack by Bulgaria, Rumania, or Hungary, or aiding Greece against a renewal of guerilla attacks abetted by its communist neighbors—in every one of these situations, we would not be able to resort to area bombardment of cities, by atomic or other weapons, as means to enforce our political aims. Everywhere, we would be facing the question of how to protect a country from subjugation, or liberate a country already subjugated by an expansionist, totalitarian political system—without decimating its people and destroying their wealth, their homes, and their beloved ancient cities and monuments.

To be successful in this kind of "war by proxy" with the Soviet Union, the United States needs considerable and adequately equipped mobile land forces, strategically located as closely as possible to the areas where an outbreak appears likely. This kind of preparedness may be more burdensome and repugnant to Americans (and more expensive) than preparations for "push-button" aerial annihilation of large cities and crowded industrial areas. It seems, however, that the first task now assumes a higher priority than the second one. The ultimate outcome of the main power contest between the U.S. and the USSR may be heavily, if not decisively, prejudiced by a series of "little wars," of the kind now fought in Korea, which may break out sporadically in the Far East, Middle East, and Eastern Europe. The existence of atomic weapons is one of the reasons (if not the main reason) why the outbreak of a "hot" war between the two main protagonists on the world stage, will long be delayed. To this extent, atomic weapons in our possession may be called (as was claimed by Churchill) guarantees of peace. But, while this precarious "peace" is preserved on the main "front," we are suffering and may suffer more defeats on secondary fronts where our atomic weapons are of no use whatsoever. Unless and until we find a way to stop the world power contest with the Soviet Union, and to replace it by peaceful competition and collaboration, we will have to undertake without further delay a considerable expansion of our mobile land forces in various strategic areas, even if it means slowing down the all-out development of weapons of mass destruction, (such as the projected hydrogen bomb) and if need be, with disregard of domestic inconvenience and a decline in the standard of living.

Another thing is important, if not decisive, for meeting the challenge of the "warm" war: An active propaganda (and, active policy, which is the best propaganda), intended to create in the countries whose freedom we profess to protect, popular belief in our intentions and active support for our cause. It is a difficult task particularly in Asian countries where liberal elements are either non-existent, or weak, corrupt, and without organizational ability or meek and lacking in fighting spirit. The memory (and continuance) of racial injustice and colonial subjugation by the Western powers, exploited by communist propaganda, must be over-

(Continued on page 217)

FREEDOM IN SCIENCE

Michael Polanyi

Professor Polanyi, eminent physical chemist and economist from the University of Manchester, Manchester, England, has recently delivered a series of lectures on "The Logic of Liberty," as Alexander White Visiting Professor at the University of Chicago. The following article is based on one of his Chicago lectures.

THE convictions which we hold concerning freedom in science rest on our beliefs on the nature of science, which in their turn are based on our general conceptions of the nature of things. Eric Ashby has recently described in a broadcast how impossible he found it to explain to communists in Russia that the pursuit of scientific discovery is different from the building of roads or power stations. Their strictly materialistic assumptions about the nature of things leave no scope for the existence of transcendent obligations, to the service of which man is pledged. This is part of their general substitution of human ideals by an idealization of appetites. We may often wonder why the Politburo, whose members are as well-read, intelligent, and public spirited as that of any government, should deliberately corrupt its scientific and technical apparatus, on which it lavishes large sums, for the sake of pursuing some cranky ideas which appear so completely silly to us here. The reason seems to me that they cannot cultivate true science without recognizing it as a mental force in its own right, submitting only to standards of its own. Totalitarianism would crumble if it accepted such limitations. But, in refusing to accept these, its governors deliver themselves into the hands of people like Lysenko, who will undertake to make discoveries to order and to bend the standards of science into subservience to the public interest as determined by the rulers of the day. The corruption of science under totalitarianism is, therefore, no mere willful excess of tyrannical powers, but the logical outcome of the principles underlying the regime.

Based on a lecture given in April, 1950, at the University of Chicago.

This will become clearer if we realize more fully, how very large are in actual fact the assumptions which underlie our conception and our practice of freedom in science.

THE ORGANIZATION OF SCIENCE

I shall examine freedom in science as a form of organization. The view generally accepted in the West and embodied in the existing practice of scientific life is that freedom in science is an efficient form of organization. The opportunity granted to mature scientists to choose and pursue their own problems is supposed to result in the best utilization of the joint efforts of all scientists in a common task. In other words: if the scientists of the world are viewed as a team setting out to explore the existing openings for discovery, it is affirmed that their efforts will be efficiently coordinated if only each is left to follow his own inclinations. It is claimed, in fact, that there is no other efficient way of organizing the team, and that any attempt to coordinate their efforts by directives of a superior authority would inevitably destroy the effectiveness of their cooperation.[1]

The coordinative power of freedom in science consists in the adjustment of each scientist's activities to the results hitherto achieved by others. In adjusting himself to the others, each scientist acts independently, yet by virtue of these several adjustments scientists keep extending together, with a maximum efficiency, the achievements of science as a whole. At each step a scientist will select from the results obtained by others those elements which he can best use for his own task and will thus make the best possible contribution to science, opening up thereby the field for other scientists to make their optimum contribution in their turn—and so on indefinitely. Following their own initiative, scientists will distribute themselves over the whole field of possible discoveries, each applying his own special ability to the task that appears most profitable to him. Thus as many trails as possible will be covered, and science will penetrate most rapidly in every direction toward that kind of hidden knowledge which is unsuspected by all until its discovery—the kind of new knowledge on which the progress of science truly depends.

The conception of freedom which I have affirmed here is somewhat unusual. It does not mention the abiding claims of the individual, nor demand with Locke that the public authority should be restricted to the service of its citizens. It starts instead from the conception of a task possessing a certain structure and asserts that any team undertaking this task must be organized by self-coordination. The kind of freedom that is defined here is a technique for the efficient societal performance of a particular type of task. Supposing the team undertook a different kind of task, say a systematic task which is not self-coordinative, liberty could no longer be claimed for its members; but on the contrary, it would be demanded that they should submit to a system of subordination. The construction of a house, or the conduct of a military campaign, or the surveying of the stars composing our galaxy—such systematic tasks can be achieved only if the participants are directed and coordinated centrally, ac-

[1] For a further discussion of the coordinative principle of science, see the author's articles, "The Foundations of Freedom in Science," *Bulletin* II (December 1, 1946), 6-7, and "The Case for Individualism," *Bulletin* V (January 1949), 19-20.

cording to plan. Nothing has been said so far why the State should not undertake to carry out a task of the latter kind and legitimately abolish all liberty in the pursuit of it.

THE SCIENTIST'S COMMITMENT

These are serious questions, to which I shall not attempt to give a complete answer. But I shall try to clarify the position so far as freedom in science is concerned. I affirm that my analysis does not reduce the status of this freedom. Our demand for freedom in science still speaks in high accents. For though freedom be only a societal technique for the accomplishment of certain tasks, some of these tasks stand over and above us. The pursuit of science is such a task. We can cultivate science only if we accept science as something real, as a system of truth which is there whether we think so or not, partly disclosed at any particular moment by the past achievements of scientists and to be disclosed even further by discoveries yet to come. We can rely on the work of others in the pursuit of this aim and adjust ourselves to them in a common system of self-coordination only if they share our vision and our hopes. This cannot be arranged by contract, for no agreed consensus would be of any value here. We must know that the others are freely committed as we are to the same beliefs about the reality of science and the prospects of discovering its yet hidden parts and trust that it is what convinces *us* of the reality of this expanding system that also convinces *them*. Each scientist will know then that the task of discovery which stands over and above him, also stands over and above others like him, and that he can rely on their understanding and support. He will know that they are convinced with him that this is a task which ought to be undertaken by man. Scientists may regard this obligation as simply unconditional. Or else they may try to define it further, either as their duty to the honor of man's intellect, or to the service of man's well-being, or perhaps to the glory of God. Such descriptions will always be inadequate: it is the commitment that matters and the fact that a group of people known to each other accept this same commitment.

By this act of commitment scientists give allegiance to principles which are not under the jurisdiction of the state or indeed of any man. As they dedicate themselves to the disclosure of a yet hidden rational system of knowledge, they demand public recognition for the task to which they thus dedicate themselves. They demand that science shall be allowed to be pursued as an aim in itself and be fostered as such unconditionally.

These larger aspects of freedom in science are all implied in the nature of science as a self-coordinative intellectual task. And we can proceed much further and derive in some detail the constitution of scientific life as logically determined by the nature of science and of the task presented by its societal pursuit. If the discoveries of different scientists are to supplement each other in the manner in which the several bits of a jigsaw puzzle fit together, they must be couched in the same idiom of basic beliefs. The findings of spiritualists, Christian Scientists, water diviners, and astrologers do not dovetail with each others' findings or with those of chemists, botanists, and astronomers, while those of the latter groups do fit into the same growing system of knowledge.

INDETERMINATE NATURE OF SCIENTIFIC BELIEFS

But the beliefs which are shared by scientists cannot be expressed in precise terms. If that were the case, discoveries could be made and verified according to strict rules, and I believe to have proved this to be logically impossible. Scientific beliefs are necessarily indeterminate. They are like rules of art. They are guides in the art of making scientific discoveries and guides of connoisseurship in assessing the value of a scientific claim. Such unspecifiable knowledge cannot be transmitted by precept. There exist in fact no textbooks which tell you how to make discoveries, nor even how exactly to verify a claim to discovery. The study of heuristics, i.e., the inquiry into the general method of solving problems in mathematics, has recently been revived by G. Polya in his book *How to Solve It*. But while this excellent work offers a collection of useful maxims, it makes it quite clear that discovery can be but little assisted by any formulated precepts. It follows that the continuity of scientific work can be maintained through successive generations only by transmission of scientific beliefs and scientific standards by *implicit* rather than by explicit communication. An unspecified message handed over from the present to the future is called a tradition; scientific beliefs and scientific standards can be transmitted only by tradition. The coherence of science is based on the common rootedness of all scientists in the same scientific tradition.

TRADITION: THE METHOD OF TRANSMITTING SCIENTIFIC BELIEFS

All tradition is transmitted by example. When entering into the labors of the older generation, those who follow after unconsciously acquire the outlook of those whom they are about to replace. A succession of generations shaping their practice on the same examples whose line is steadily lengthened by the addition of new names in the course of time, upholds a continuous tradition through time.

Such is the case in science. In spite of the profound changes in general outlook and method which have occurred in the last four hundred years of scientific development, I could hardly mention a scientist of the whole of this period who was highly respected in his own time and has subsequently lost his rank among scientists, and few have been added to the ranks of great scientists by a later generation whose works were generally thought valueless in their own days. It is true that many of Kepler's, or even Galileo's or Newton's arguments may appear irrelevant today. And again, Galileo and Newton would probably be profoundly unsatisfied with the kind of explanation quantum mechanics gives us of atomic processes. But Galileo and Newton remain, nevertheless, classics of modern science. Their discoveries are the very foundations of the picture which we are forming of nature today and their methods of investigation are still among the archetypes of the modern scientific method. Their personal example is recognized with unchanging loyalty and indeed with a reverence which increases through the centuries as the realm of science, which they founded, continues to extend its domain. Science remains defined as the search for truth on the lines set by the examples of Galileo and his contemporaries. No pioneer of science, however revolutionary — neither Pasteur, Darwin, Freud, nor Einstein —has denied the validity of that tradition, nor even relaxed it in the least.

The art of scientific work is so extensive and manifold that only a large number of specialists can pass it on from one generation to another, each of whom fosters one particular branch of the art. Therefore, science can exist and continue to prosper only in so far as its premises are embodied in a tradition which is held in common by a community. Though each scientist knows only his own subject and often cannot understand even the titles of the papers published by his colleagues, scientists know each other as fellow-scientists.

Only those who thus recognize each other as carriers of the same tradition are admitted as contributors to the piecing-together of the great hidden puzzle. The current cross-section of the tradition is reflected in the prevailing scientific opinion, and it is this opinion which grants recognition to scientists as scientists and dismisses others as cranks, frauds, or ignorant blunderers vainly trying to pass as scientists.

THE EVALUATION OF THE RESULTS OF RESEARCH

Freedom as a technique of organization relies on the immediate publication of discoveries. If science were like a giant jigsaw puzzle, it would usually be obvious whether or not a new piece fitted into a gap into which it was pushed. But as a rule that is not true for a new discovery. Its author may think so, but he might be mistaken. His claims may be unfounded; he may have relied on insufficient evidence or embarked on unacceptable suppositions. Or his calculations may contain a crucial mistake. Moreover, the reliability of a result is not the only standard by which a proposed contribution to science is accepted or rejected. For example, an accurate determination of the speed at which water flows in the gutter at a particular moment of time is not a contribution of science. All scientific work must have some bearing on the system of science and have at least *some* interest in itself, either for contemplation or practice. These three—validity, profundity, and intrinsic human interest—underlie jointly the valuation of scientific results.

Suppose for a moment that no selection according to soundness and value were imposed on the publication of scientific contributions in journals. The selection — which is indispensable in view of the limited available space— would then have to be done by some neutral method, say by drawing lots. Immediately the journals would be flooded with rubbish, and valuable work would be crowded out and banished to obscurity. Cranks are always abounding who will send in spates of nonsense. Immature, confused, fantastic, or else plodding, pedestrian, irrelevant material would be pouring in. Swindlers and bunglers combining all variants of deception and self-deception would seek publicity. And buried among so much that is specious or slipshod, the few remaining valuable publications could hardly have a chance of being recognized. The swift and reliable contacts by which scientists today keep each other informed would be broken; scientists would be isolated and their mutual reliance and cooperation paralyzed.

To prevent this from happening and to preserve the functions of publicity for the continued self-coordination of scientists, scientific opinion must exercise its authority in imposing scientific standards on contributions to learned journals. Their editors and the referees called in on each occasion are made responsible for excluding all matter that they consider unsound or irrelevant. They are the agents of scientific opinion which guides their actions in conformity with the traditions of science.

THE AUTHORITY OF SCIENTIFIC OPINION

The authority exercised by scientific opinion is merely selective, not directive. It acts as a public valuer, as the guardian of weights and measures, and as a public testing-station for the whole field of scientific life. There are many opportunities for this regulative function of scientific opinion, apart from the refereeing of papers; in fact so many that I can only mention some of them here. The publication of a paper in a learned journal does by no means entail the acceptance of its claims by science. The response given to it by scientific opinion may vary greatly. Otto Hahn's brief publication on the subject of atomic fission in January 1939 evoked within a year some 150 papers confirming and elaborating his discovery. By contrast, a paper published in the Proceedings of the Royal Society by Lord Rayleigh in May 1947, which made claims of at least equal importance for the field of atomic physics, and which, to the non-specialist may well have seemed just as well documented as Hahn's paper, was unhesitatingly brushed aside as unsound; even though not one physicist I consulted on the subject could point out any error in Lord Rayleigh's experiments, or explain his results differently than he did. They just did not believe in them and thought it a waste of time to hunt for the mistake which accounted for the results. The varied responses of scientific opinion to current scientific publications should help to guide the attention of scientists toward the real growing points of science and should warn them of specious hopes and blind alleys.

Scientific opinion itself cannot be said to exist except as the opinions expressed by persons who are recognized as scientists. A person is not a scientist simply because he says that he is one, and it is a primary function of scientific opinion to determine who shall have a voice in the formation of such opinion. The mutual recognition of scientists by each other is indispensable to the existence of science as a coherent activity. Without it, the mutual adjustment of each scientist's program to the achievements of the others would be cut off. The process of compiling and accrediting textbooks, of making scientific appointments, of establishing scientific institutions, could no longer be guided by current scientific opinion and decisions taken in these matters would become disjointed, arbitrary, and presumably determined by other interests than those of science. It would not only become practically meaningless to describe anyone as a scientist, but even to refer to any statement as a scientific proposition. Science would become, in effect, extinct.

Hence, a society which wants to foster science must accept the authority of scientific opinion. It must allow it freely to exercise all those regulative functions over scientific life which are indispensable to the process of self-coordination and indeed to the very existence of science. Any society, any public opinion, or public authority, which does not defer to the natural self-government of science cannot hope to see science flourishing within its realm. Scientists have been accused of demanding that society should pay them for their own amusement. This accusation is false, for the interests of scientists are shared by an enormous public. It is doubtful whether the immense technical consequences of our increased knowledge of nature have affected the world as profoundly as the discoveries of Copernicus, Newton, and Darwin, the practical values of which were negligible. There are good reasons therefore to demand popular respect for science on the same grounds on which scientists themselves stand when dedicating themselves to science. But even if that were not so, even if society at large were only interested in the advantages to be derived from scientific progress for the material well-being of men, the same logic would inexorably hold. Science

could still be cultivated only as an autonomous body setting itself its own aims in the light of its own tradition, and guided by the authority of scientific opinion.

The part to play by a society which, for whatever reasons, wishes to foster science can only be to offer opportunities for the pursuit of science. It should provide facilities for every good scientist to pursue his own interest in science, to be recognized as a good scientist.

THE CONSTITUTION OF SCIENTIFIC LIFE

Here you have in main details the constitution of scientific life, derived from the nature of the societal task to which the scientific community applies itself. The sharing of a set of non-specifiable beliefs on which the acceptance of science rests was seen to imply a joint rootedness in a tradition. A tradition of unspecifiable beliefs and standards is reflected at any particular moment by a public opinion. Scientific opinion guards the channels of scientific communication and exercises indispensable selective functions all over scientific life. Its coherence and governance is indeed a condition for the very existence of science as a recognizable entity. Scientific opinion must also act as the trustee of society as a whole for the distribution of funds allocated by society to the cultivation of science.

This picture, however, is only a snapshot which has yet to be amended to allow for the passage of time. The ranks of scientists must be continually replenished by newcomers from the younger generation. Like the rules of many other arts, the beliefs and standards of science are passed on to the novice by personal collaboration between masters and apprentices. Scientific tradition is passed on to the next generation in the research schools of great scientists. It is by joining such a school and following in practice the example of its leader that the novice accepts the tradition of science and becomes an aspirant to membership in the scientific community.

This voluntary affiliation of young people as candidates to the scientific profession and the co-option to full membership of those among the candidates who fulfil the tests imposed by scientific opinion, represents the process by which the consensus of science is continuously maintained through time. We have here the primary acts of submission and accolade by which the authority of scientific opinion is recognized and renewed on occasion of each new entry to the profession. The learning of science as a profession is seen to coincide with the joining of the fellowship of scientists and the acceptance of the government by which this fellowship must be ruled.

TRUTH, THE HIGHEST AUTHORITY IN SCIENCE

Let me try to face at this vital point of the constitution of science a question which you probably have already felt arising before at various stages of my analysis. In what sense can a young genius, destined to remold the existing scientific outlook—the young Pasteur or the young Einstein—be said to submit to the authority of scientific opinion? And again, does not the teacher who would try to impose any authority on the young student necessarily stifle the originality of the future scientist which it is his task to foster?

The answer is in two parts. Firstly, no one who rejects all the accepted examples of scientific achievement can be said to join the scientific profession. I have said already that not even the most radical revolutionary in science has ever made such pretensions of innovation. Secondly, no scientific authority should ever speak in its own name. Its function is to transmit its own conception of the traditions of science, including the current scientific beliefs about the general nature of things. It is within the competence of scientific opinion to teach, appraise, select, and generally to act on the strength of its momentary convictions. But it only speaks as a servant of the truth and expects at any moment to be met with an appeal against its interpretation of it. All scientists, whether teachers or pupils, innovators or conservatives, fundamentally recognize the same grounds of ultimate decision in the hidden truth which it is their task to disclose. The innovator does not deny the authority of scientific opinion as a form of government, but merely appeals from scientific opinion *as it is* to scientific opinion *as it should be;* and this is an appeal which scientific opinion will never deny in principle.

It has been said that the Constitution of the United States is what the Supreme Court says it is. The fact is, of course, that the Supreme Court ought to declare what the Constitution truly is. Similarly, science is not what scientific opinion says it is but what scientific opinion *ought* to say it is. Scientific consensus can properly emerge only by a discussion based on the mutual grounds of the same scientific convictions. It cannot be negotiated in manner of a contract, nor decided by any voting procedure. Kipling's village that voted the earth was flat was acting beyond its powers, but the Royal Society would be equally talking nonsense if it tried to decide by vote whether extrasensory perception does exist or not. The consensus of scientific opinion is not something made, but something grown and given. By continuing sincerely to listen to our scientific conscience, we may assist its uncorrupted preservation. But it is not within the power of man to secure the continued coherence of the scientific body. We can only hope that it will be preserved "from false doctrine, heresy, and schism." Indeed, the constitution of science rests ultimately on something that can be logically referred to only in fiduciary terms. We cannot *observe* it but can only say that we *believe in it;* that we believe in the reality of science as an expanding system of truth, which ought to command assent and which is therefore attracting the sincere devotion of students who will always find agreement by fair discussion.

THE MEANING OF FREEDOM IN SCIENCE

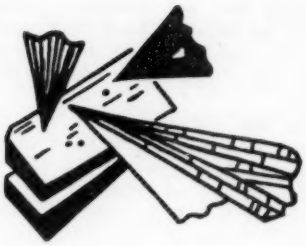
Such are the implications of freedom as a method of self-coordination. Its conception is not unrelated to that of the individual, demanding free play for the fulfilment of his personal faculties. But it is far more specific in defining the conditions and implications of intellectual freedom.

Looser definitions of freedom were probably sufficient in times when freedom had never been seriously challenged. But today such definitions remind me of people who direct me in the streets and conclude with the ominous addition: "You can't miss it." Of course the person asked knows his way, hence he feels that "he can't miss it." But once the path of liberty has become as uncertain as it is today, the "you can't miss it" definitions will not do any longer.

Take the distinction between pure and applied science which is radically denied by the philosophy of the Soviet

(Continued on page 224)

HOW EFFECTIVE ARE RADIOACTIVE POISONS IN WARFARE?



Louis N. Ridenour

An important phenomenon of the atomic age is the availability of radioactive substances in quantities millions of times larger than in the old days of radium at $25,000 per gram. The radiations of radioactive substances, as everybody knows, are dangerous to life. This suggests that radioactivity can be used as a military weapon; and, indeed, the Smyth Report of 1945 has already referred to such a proposal. In the five years since, the idea has not been publicly pursued much further. The Bulletin noticed, some time ago, that Professor Thirring, of Vienna, had published in a postwar Austrian journal an estimate of the effectiveness of radioactive poisons as a tool of warfare. The editors asked Professor Ridenour, Dean of the Graduate School at the University of Illinois, to brief Thirring's article for their readers. Dean Ridenour is a physicist who has had experience with military affairs in the last war, particularly in connection with the development and use of radar, but was not and is not now officially connected with the American atomic energy project.

IN ONE rather brief section of the celebrated Smyth Report, we read:

"In a chain-reacting pile . . . radioactive fission products build up as the reaction proceeds...Since they differ chemically from the uranium, it should be possible to extract them and use them like a particularly vicious form of poison gas. This idea was mentioned in the National Academy Report and was developed in a report written December 10, 1941, by E. Wigner and H. D. Smyth, who concluded that the fission products produced in one day's run of a 100,000 kw chain-reacting pile might be sufficient to make a large area uninhabitable."[1]

Since then, not much has been heard about *radiological warfare*, as the willful use of radioactive substances for military purposes has come to be called. A few usually veiled and always qualitative references to it have appeared in popular comments on atomic weapons and techniques. The times being as they are, such a vacuum of comment can be taken to mean either (*a*) that radiological warfare is regarded as being unpromising, and is therefore being ignored, or (*b*) that the use of fission products as a weapon seems highly significant, is being vigorously investigated, and is being kept classified.

Without inquiring which of these alternatives is the true cause of the current silence, the physicist who has access only to the open literature of his science can make some interesting and reasonably reliable estimates of the potential importance of fission products as a weapon. Precisely this has been done by Hans Thirring, Professor of Physics at the University of Vienna, in a paper published about two years ago.[2]

Thirring, it will be remembered, made some fairly accurate remarks about thermal superbombs a few years before the hydrogen bomb became a topic of dinner-table and editorial-page discussion in this country. It may be worth while to present the results of his considerations on radiological warfare, and this is the aim of the present article.

First of all, let us be clear on the subject we are discussing. Broadly interpreted, the term "radiological warfare" refers to the delivery to an enemy target of radioactive materials in such concentration as to endanger the lives of those present there. These radioactive materials may have originated in any one of three major ways, only one of which we shall, following Thirring, discuss in any detail. The other two, however, are worthy of brief mention.

RADIOACTIVE INFECTION AS A BY-PRODUCT OF A-BOMB EXPLOSION

The radioactive substances infecting an enemy target may have their origin in the actual explosion of an atomic bomb. As everyone knows, very large quantities of radioactive substances are formed in less than a microsecond by the uranium or plutonium fission which occurs when an atomic bomb is detonated. In the combat use of atomic bombs at Hiroshima and Nagasaki, the bomb was set to detonate high enough above ground so that the radioactive products of the explosion rose high into the air and were carried many miles out over the Pacific by winds as they decayed and settled gently from the upper atmosphere.

This high-altitude bomb burst was chosen for two reasons, we are told. First, the altitude chosen was calculated to be that at which the blast effect of the bomb would spread over the maximum area. Second, a high burst made it reasonably certain that the deposition of radioactive fission products at the target would be of negligible importance (unless the bomb was dropped in a rainstorm), so that the American forces could not be accused of resorting to a new and inhuman form of warfare. Both major expectations were fulfilled, but the consequence of the

[1] H. D. Smyth, *Atomic Energy for Military Purposes* (Princeton, 1945), Section 4.27.

[2] Hans Thirring: Ueber das moegliche Ausmass einer radioaktiven Verseuchung durch die Spaltprodukte des U-235, *Acta Physica Austriaca* II (1948), 379-400.

second was not altogether realized; America found the bomb itself regarded as a somewhat inhuman weapon, despite the lack of logic that is inherent in this view.

In Test Baker at Bikini, an atomic bomb was exploded a short distance beneath the surface of the sea. The blast damage so produced was fatal only to a few ships relatively near the bomb. However, the contamination caused by spray carrying radioactive elements resulting from the explosion was so severe that it has caused the eventual scrapping of essentially the whole target fleet. This shows clearly that the lingering radioactive poisoning of a target, which we call radiological warfare, can be accomplished as a result of an atomic bomb explosion. The radioactive poisons which result from the explosion are partly fission products—the broken halves of a fissioned uranium or plutonium atom—and partly radioelements formed from stable atoms which have captured one of the neutrons which an atomic-bomb explosion emits in such abundance.

In the case of a hydrogen bomb, no radioactive analogues of the fission products are produced by the fusion reaction. The fission bomb used as a detonator will, of course, produce radioactive fission products. The neutron emission attending a fusion-bomb explosion being copious, these fission products can be supplemented by intense neutron-capture radioactivity if a suitable neutron-absorbing material is incorporated in the bomb for that specific purpose.

Thirring does not mention the radioactive poisoning of a target by the detonation of atomic bombs, and we shall pursue the subject no further here.

SPECIFICALLY DESIGNED RADIOACTIVE POISONS

We shall speak, instead, of the delivery to a target of radioactive materials fabricated at home for that purpose. This is a novel type of warfare, in that it produces no destruction, except to life. Even the hazard to life and health is short-lived, its duration being governed by the lifetime of the radioactive materials used.

Radioactive poisoning of this sort is a novel thing. It can be regarded as a horrid and insidious weapon, since the person in a poisoned area has no way of knowing that he is in danger, either by the evidence of his senses or by any unsophisticated test. He may receive a lethal dose of radiation two weeks before he knows that he is endangered, and yet a few days later he may be dead.

On the other hand, this weapon can be regarded as a remarkably humane one. In a sense, it gives each member of the target population a choice of whether he will live or die. For, as we shall see, the concentrations of radioactivity that it is practicable to use will surely kill a person who remains in the affected area a month, while giving an excellent chance of survival to a person who flees at once, with a folded, dampened, handkerchief over his nose and mouth. The high-explosive and incendiary bombs of the last war gave the target population no such choice. They killed you or they didn't, and the issue was decided in a flash, without your participation in the judgment.

SUBSTANCES MADE BY NEUTRON BOMBARDMENT

The radioactive substances intended for military use can be made in either of two major ways, of which Thirring discusses only one. The one he does not discuss is the manufacture of such materials by exposing a suitably chosen stable element to neutron bombardment in a reactor, in order to render it radioactive. We shall here dismiss this possibility, too.

For, each radioactive atom made in such a way captures and therefore uses up a neutron. If that neutron, instead of being used in this way, were used to make plutonium from uranium, we should then have manufactured an atom of nuclear fuel which, upon absorbing another neutron, would liberate an energy of some 200 millions of electron volts. This corresponds to an energy yield of more than 100 million electron volts per neutron. Alternatively, had we used the neutron to make an artificial radioelement such as, for example, sodium 24 from natural sodium 23, we should have obtained from using up the neutron only a few millions of electron volts. Manufacture of neutron-capture radioelements in a nuclear reactor is, therefore, a very unrewarding energetic alternative to the manufacture of nuclear fuels such as plutonium.

This brings us at last to what Thirring *does* discuss. He discusses what is mentioned in the section quoted from the Smyth Report: the separation of fission products from the processed uranium emerging from a reactor, in order that such fission products may be used as radioactive poisons.

As is well known, each uranium atom, when it fissions, splits into two lighter atoms. It can do this in a variety of ways, producing in each event of fission any two of some 300 nuclear species that have been identified among the fission products. In general, each of these fission products has a neutron excess, as compared with its chemically identical isotopes. It therefore transforms itself into a stable atomic type by the so-called beta radioactivity, whose consequences are the transformation of a nuclear neutron into a proton, with the ejection of an energetic negative electron, or beta particle. The resulting nuclear rearrangement is often, though not always, accompanied by the emission of penetrating gamma rays.

This, then, is the genesis of the radioactive poisons which are fission products. In a nuclear reactor immense amounts of them are formed. Obviously, not all fission products will be useful weapons in radiological warfare. Thirring restricts his attention to a dozen "useful" fission products. These are selected on the criteria that they should:

a) be produced in substantial quantity by fission; some types of fission fragments are produced quite often, others only rarely;

b) emit beta or gamma rays of substantial energy and therefore of substantial penetrating power; and

c) have a half-life in the range from about eight days to a year or so; fission products of shorter life will disappear before they can be separated, processed for dispersal, and transported to a target, while fission products of longer life have too low a specific activity.

INTERPRETATION OF TABLE I

The fission products selected by Thirring on the basis of these criteria are shown, with their properties, in Table 1. The "yield" shown in the fifth column of that table means, for example, that of 1,000 atoms of uranium undergoing fission, 64 will divide in such a way as to produce an atom of zirconium 95; each of these Zr^{95} atoms will decay into columbium 95, its radioactive daughter. Cerium 144, while listed in the table, is of significance only in terms of its daughter, praseodymium 144. The latter emits radiation energetic enough to be important, while the former does not; however, the short lifetime of Pr^{144} would make it useless for the present purpose were it not that the short-lived Pr^{144} is continually produced by the decay of the long-lived Ce^{144}.

Table 1 shows that, for every 100 uranium fissions, 61 atoms effective in radiological warfare are produced. We

TABLE 1

FISSION PRODUCTS USEFUL IN WARFARE

Atomic Number	Chemical Symbol	Half-Life	Radiation Emitted	Yield in Atom per cent	Energy of Radiation, Mev.	
					Beta	Gamma
38	Sr^{89}	53 days	Beta	4.6	1.5	—
39	Y^{91}	57 days	Beta	5.9	1.6	—
40	Zr^{95}	65 days	Beta, Gamma	6.4	0.4	0.8
41	Cb^{95}	35 days	Beta, Gamma	6.4	0.7	0.8
44	Ru^{103}	42 days	Beta, Gamma	3.7	0.2	0.5
53	I^{131}	8 days	Beta, Gamma	2.8	0.6	0.4
56	Ba^{140}	12.8 days	Beta, Gamma	6.1	1.0	0.5
57	La^{140}	40 hours	Beta, Gamma	6.1	1.7	{ 1.7 { 2.0
58	Ce^{141}	28 days	Beta, Gamma	5.7	0.6	0.2
58	Ce^{144}	275 days	weak Beta	—	—	—
59	Pr^{144}	17.5 min	Beta, Gamma	5.3	3.0	0.14
59	Pr^{143}	14 days	Beta	5.4	1.0	—
60	Nd^{147}	11 days	Beta, Gamma	2.6	0.9	0.6
				61.0		

can readily relate this result to the operating power level of a nuclear reactor in which large numbers of fissions are occurring each second. The power level of the reactor can be measured in kilowatts; for each kilowatt, about 3×10^{13} fissions take place each second. The unit of activity for radioactive preparations is the "curie," defined to be that quantity of radioactive substance in which 3.7×10^{10} radioactive disintegrations occur per second. Using the "efficiency" of 61 per cent taken from Table 1, we see that about 500 curies of militarily useful radioactive atoms, of the kinds listed in Table 1, are produced when a nuclear reactor operates at a power level of one kilowatt.

These 500 curies per kilowatt do not spring into being the instant the reactor is turned on. Instead, the quantity of fission products present builds up from zero toward an equilibrium value of 500 curies per kilowatt, which is attained only when the reactor has been running for a very long time. The time which must elapse before this final value is approached to any given degree depends on the half-lives of the radioelements involved, and can be computed from the well-known laws of radioactive decay. Thirring has made this computation for his "useful" isotopes and finds that, after one month, half the final activity will be present; after a year, nearly all of it (96 per cent).

Instead of speaking in terms of kilowatt reactors, we should talk of reactors whose power is measured in millions of kilowatts. The Smyth Report indicates that the total power of the three original reactors at the Hanford works was around a million kilowatts. The new construction announced since then has doubtless at least trebled the original installation, and may have done more. For each million kilowatts of reactor power—that is, for the original installation at Hanford—500 million curies of "useful" fission products are ultimately produced. Each month's production amounts to some 250 million curies. Supposing that the presently existing Hanford installation runs at a power level of three million kilowatts—which seems a reasonable assumption—we are there producing, as you read this, 750 million curies per month of deadly poisons.

LETHAL POTENTIAL PER GROUND AREA

Seven hundred fifty millions is a large number, but is the curie a large unit? How much ground area could be poisoned by the use of this material? It is with this question that Thirring largely deals. To answer it, he breaks it down into several smaller questions. First, what dose of radiation is required to kill a human being? Second, supposing radioactive material to be spread uniformly over the ground with known concentration, what dose will be given to persons living and working in the area? Third, how shall we take into account, in addition to the effects of radiation coming from the radioactive layer on the ground, the effects of inhalation of radioactive dust?

The unit of X-ray or gamma-ray dosage is called the "roentgen" or r unit. Thirring surveys the existing literature on radiation damage and concludes that a dose of 2,000 r units received by the whole body of a man will almost inevitably produce death. This is between four and five times the minimum fatal dose, according to the most reliable existing estimates. A dose only one-tenth as great can be expected to produce non-fatal radiation sickness in susceptible individuals, and to present the hazard of genetic damage to all.

Let us now inquire, with Thirring, what concentration of radioactive poisons, dispersed as a uniform layer on the ground, is needed to give in, say, one month, a dosage in the order of the fatal 2,000 r. We first observe that the energies of the gamma rays listed in Table 1 are not so different from the energies of the gamma rays emitted by a capsule of radium in equilibrium with its decay products, when the latter radiation is filtered through half a millimeter of platinum. It will therefore be reasonably accurate for the present purpose to treat the gamma radiation from our mixture of fission products as being identical with the radiation from a filtered radium source.

A filtered radium source produces a radiation intensity of 8 r per hour per milligram of radium, at a distance of 1 cm from the source. At greater distances, the intensity is reduced according to the usual inverse-square law. Only two of the nine radioelements present in the radium preparation, Radium B and Radium C, emit radiation penetrating enough to get through the platinum filter; each of these two radioelements is decaying at a rate corresponding to 3.7×10^7 disintegrations per second, or one millicurie. Thus, the radium preparation has an effective strength, in terms of disintegration rate, of two millicuries: one for Radium B and one for Radium C. Better said, the radium preparation produces about the same gamma-ray intensity as would two millicuries of our mixture of fission products. This means that each curie of the fission-product mixture will produce, at a distance of one centimeter, a radiation intensity of $8/2 \times 1{,}000 = 4{,}000$ r per hour.

RADIATION INTENSITY

Several more considerations must enter the calculation. To get the radiation intensity at a given height above an infinite radioactive plane, we must make a calculation which includes both the geometrical factors and an allowance for the absorption in air of the gamma rays from each elementary area of the plane. The heights above the ground which are of interest here are, of course, those corresponding to the location of the vital areas of a standing man.

Again, not all of the "useful" isotopes listed in Table 1 emit gamma rays. The

gamma-ray emitters amount altogether to some 45 atom per cent of fissions, out of the 61 atom per cent represented by the total of the "useful" fission products. They thus make up 45/61 or 74 per cent of the total activity of the fission products.

TIME DECAY

Finally, the fission products decay quite rapidly with time. The mean half-life for the mixture of fission products is about one month; using this yields the result that the average dosage rate, over a month, is only 0.722 times the initial dosage rate.

Similar considerations apply to the beta rays emitted by 33 atom per cent of the isotopes listed in Table 1. These then amount to 33/61—55 per cent of the "useful" fission products, if we limit ourselves to isotopes which emit beta rays of energy one million electron volts or more. These beta rays have a higher absorption coefficient in air, but the geometrical calculation is otherwise the same. If they reach a living body, they have, curie for curie, thirty times the deleterious physiological effect of the gamma rays. The mean half-life can be taken to be about the same as that of the gamma-ray emitters.

Collecting all these results, we get the numbers shown in Table 2, where S stands for the surface density of radioactive infection in curies per square meter.

It is useful to consider the gamma-ray dose and the beta-ray dose separately, not only because they must be separately calculated, but also because the effect of the beta rays can be substantially eliminated if heavy clothing is worn, since the beta rays are relatively readily absorbed. We see from Table 2 that a surface density of radioactivity amounting to one curie per square meter will produce, at the center of an erect man's body, an initial gamma-ray intensity of 4 r/hour, and a monthly dose that will be surely lethal. Any beta rays that penetrate through clothing will increase this dose.

SHIELDING

Of course, we have not yet taken into account another factor which may affect the monthly dose: the amount of time that an individual spends inside a sturdy building which can provide good radiation shielding. It is difficult, and scarcely worth while, to be too precise about these matters. We can conclude from the foregoing that a whole-body dose of 2,000 r—a fully lethal dose—is likely to be received by most people who continue their normal activities in a region where radioactive poisons have been spread to the extent of one or two curies per square meter.

TABLE 2

EFFECTIVENESS OF RADIOACTIVE INFECTION

(S is surface radioactivity in curies per square meter.)

	Height above Ground		
	50 cm	100 cm	150 cm
Initial gamma-ray dose rate, r/hr	4.6 S	4.0 S	3.6 S
Initial beta-ray dose rate, r/hr	20.6 S	11.5 S	7.0 S
Total initial dose rate, r/hr	25.2 S	15.5 S	10.6 S
Monthly gamma-ray dose, r	2400 S	2080 S	1880 S
Monthly beta-ray dose, r	10700 S	5980 S	3640 S
Total monthly dose, r	13100 S	8060 S	5520 S

DEADLINESS OF RADIUM INGESTION

Besides enduring radiation from radioactive material spread on the ground, the inhabitants of an infected area face one more major hazard. This is the danger of inhaling and retaining in the lungs a sufficient quantity of airborne radioactive particles to kill them by internal radiation. By making a comparison with the clinical data on the effects of ingesting radium, Thirring here concludes that about one-tenth of a millicurie of fission products is likely to produce death if retained inside the body.

The likelihood of breathing in and retaining this amount of fission products depends upon a number of factors, including the manner in which the radioactive material is prepared for dispersal, the concentration on the ground, the condition of the ground surface, and the strength of the prevailing winds. The smaller the radioactive particles, the more easily they will be airborne. They must not be too small, however. Thirring says that, while particles of 3 microns diameter are 80 per cent retained within the body, smaller particles are breathed in and out with less retention.

Thirring points out that particles lying on the level streets of a large city will be readily picked up and dispersed by the winds. He estimates, that, in regions where the surface contamination amounts to 2 curies per square meter, the concentration of radioactive dust a few feet from the ground is likely to be such that a fatal internal dose can be ingested by taking 500 breaths. This will occupy the normal person about half an hour. It can be evaded, of course, by a simple respirator.

RADIOACTIVE POISONS AS BY-PRODUCT OF ATOMIC POWER

The last section of Thirring's paper is devoted to the computation of the area that can be contaminated by the fission products incidental to the operation of part of the electrical industry of the U.S. on atomic power. He neglects altogether the bomb plants. It is his point here that, even though atomic bombs might be renounced by international agreement, still the peaceful exploitation of atomic power presents every industrial nation with an atomic weapon in the shape of the fission products.

His assumptions are: first, that the total electrical power capacity of the U.S. will be 60 million kilowatts in 1960 (it was actually 55 million kilowatts in 1948, so that this is probably conservative); second, that in 1960 one-fifth of this power will be generated in atomic plants (a highly optimistic supposition, the way that things are going); and third, that the over-all efficiency of the power generation is 33 per cent, so that the 12 million kilowatts of electrical power supposed to be generated by atomic energy will require 36 million kilowatts of thermal atomic power.

We have already seen that 2 curies per square meter is a very dangerous concentration of radioactive infection with the fission products Thirring picks out. Also, we have seen that the monthly production of these fission products in a reactor is 250 curies per kilowatt. It follows that, for every million kilowatts of reactor power, we can contaminate to the level of two curies per

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NEUTRALITY FOR FRANCE?

Etienne Gilson

Two articles on the question of neutrality for Western Europe have previously appeared in the Bulletin. In the first (October 1949), Professor Leo Szilard advocated neutrality of France and other countries of Western Europe as a buffer between the two hostile powers, the U.S. and the USSR. A rebuttal of his arguments was given in the April issue by Professor Raymond Aron, a French sociologist. In the following article, a well-known French Catholic philosopher, Dr. Gilson, argues the case for neutrality as a practically feasible policy.

THE idea that France can remain neutral in an almost world-wide conflict arouses a feeling of incredulity. But conceding that the hypothesis seems at first sight to be false and even vicious, this is no reason for refusing, a priori, to examine it. Especially as it has recently received a quite unexpected reinforcement from the arguments employed by its opponents. This idea, so ridiculous that it ought to be possible to demolish it in five lines, is apparently resisting, with some success, the effort to demonstrate its absurdity. The very poverty of the arguments used against it amounts, in the end, to a favorable recommendation, and one feels, in reading them, that the discussion would be improved by the introduction of reasoning which was at least worth the trouble of refuting.

NEUTRALITY NOT A SIGN OF COWARDICE

It is certainly possible to refuse to examine the thesis, but it is not very reasonable, for one accepts no commitments in undertaking to examine a few aspects of a problem, beyond the disinclination to regard the issues as already settled. The undeniable fact that the idea of a neutral France offends our conscience, and, to speak frankly, awakens some distaste in all of us, is explained by the romantic tradition which has persisted throughout our national history and literature. There is something of a Cyrano in the hearts of many Frenchmen, and in the imagination of all of us. "I fight, I fight, I fight!" It is a misfortune that neutrality rhymes so perfectly with poltroonery (*neutre-pleutre*), and in a country where words have the power which they exercise here, facts like these should not be dismissed lightly. They are more than facts: they are almost arguments.

Observe, however, that they have little weight among those countries, in effect neutral since the last world war, whom we sometimes envy for their skill or good luck, though usually with a mixture of condescension. These peoples do not in the least consider themselves as cowards who refuse to fight. On the contrary, they are firmly resolved to do so, but they refuse to involve themselves in quarrels which do not affect their national interest, and they prepare to take up arms only to resist a threat to the soil of their fatherland. The Swiss army exists: it has the interesting feature of training soldiers how to use their rifles as distinct from merely cleaning them. Sweden is armed: she has a not insignificant fleet, an excellent air force, and a firm determination to resist aggressors. The patriotism of these countries is not less than ours, and their neutrality is not at all to be confused with material or moral disarmament. On the contrary, they sometimes permit themselves to be politely surprised at the spectacle of other countries exhibiting a magnificent disdain for neutrality while neglecting to command the minimum resources for self-defense. The first essentials for neutrality are a strong army and the will to fight every aggressor, however powerful, to the limit.

NEUTRALITY NOT A DEFEATIST ATTITUDE

So be it: it will be said that neutrality, if not to be identified with cowardice or lack of patriotism, is nonetheless defeatist, for in declining, in advance, all responsibility which is not narrowly national, a people abdicates the authority which it might exercise in the world, and so far from wishing to count among the victors of some future war, it implicitly resigns itself to a place among the vanquished. It will be ignored in any disposition of the fate of this planet: as a great people, it is finished.

This is by no means a weak objection, and it may be said to have weight for every people destined by their virtues, their present power, and the circumstances of history, for the role of arbiter in the political world. Even so, it is more important to have an army than to indulge in solemn pronouncements about what one will do with it; and to recognize, if one has an army, that the problem of how to employ it takes one form for those who are arbiters of the world and another for those whom they invite to join them in the next war. It is not enough to feel confident that one of the protagonists will win—the recent example of Italy shows that there are risks in rushing to the aid of the

victor. It is essential to remember that the real victor in modern war has not merely to prevail over the common enemy but also over his own allies. At the end of one of these world conflicts, in which peoples commit the totality of their beings and resources, it is survival power which counts; and as this suffers in direct proportion to the courage and totality of the sacrifices, the great art of war is now to conduct it in such a manner as to leave the victor unembarrassed by either his allies or his enemies.

We learned this in 1919. The history of the inter-war years should have left no doubt about the burden which the victor bears in the political world, when, bled white by the common victory, he is reproached by the allies of yesterday with the double offense of having caused the war and sabotaged the peace. Nothing is neglected to hinder him from rebuilding the power which he rashly sacrificed for the common cause. And what assiduous attentions are lavished on yesterday's enemy to enable him to check some embarrassing ally! Let us remember the period so well described by Frank Monaghan in his *History of the Second World War*, when American money flowed so bountifully into Germany that "for each dollar of reparations paid by her to France and England, Germany received two dollars from the USA." Nothing is more natural; and England in her turn is discovering today how costly is the formula—even to an empire as powerful as hers—"supply us the arms, and we will supply the men." The dead are dead; the survivors must pay for the arms; and the moral victor of the war, which expected to emerge from it as a great world power, discovers in dealing with its allies of yesterday that it is only a gallant cripple. Let us not conclude from this that neutrality must be adopted; but if it is rejected because it implies some kind of refusal to arm oneself, to fight, or to take one's proper place in the world, then it must be admitted that these objections are not self-evident.

WOULD RUSSIA VIOLATE FRENCH NEUTRALITY?

It is far from certain that neutrality would be either advisable or even possible for our country, but if public opinion means anything to us, it is desirable not to settle the problem without examining it. What is the use, say the critics of neutrality, of declaring ourselves neutral in a possible future conflict, when we know in advance that this neutrality would be violated by the Soviet Union? And, in fact, if we know this, then what good can come? But *do* we know it?

Those who claim this knowledge might do well to recall the other prophets of calamity, all of whose predictions were not fulfilled. In the course of the last war, Hitler, sooner or later, ought to have invaded Switzerland; to have quietly crossed Spain in order to take Gibraltar, key to the Mediterranean, from the rear; and to have installed

himself in Sweden without firing a shot, instead of paradoxically turning through Denmark and Norway. It is freely admitted that these predictions were entirely reasonable, but, in fact, none of them came true. We were astounded when the Moscow government, allies of the government in Washington, left the American army alone in the field for such a long period in the war against the Japanese, who were allies of Germany, with whom Russia was then at war—as if the allies of our enemies were not our enemies. Naturally, today we are lavishly supplied with reasons for what happened, but do those who invent or discover them know any better in 1950 what Russia will do in 1960 than they knew in 1940 what she was going to do in the ensuing years? It is certain that, even powerfully armed and firmly resolved to defend herself, France would be exposed to attack. That such a violation of her neutrality would be probable, or even very likely, is perfectly credible; but, inasmuch as those who predict this as a certainty are not in possession of the most highly guarded secrets of Soviet politics, it is surely not unfair to them to protest that they do not know. The highest probabilities are not certainties, and it is harder than one thinks to calculate probabilities in this matter.

REASONS BEHIND THE SOVIET DREAD OF WAR

Russia is at present engaged in an economic experiment whose success or failure will, in the final analysis, be that of the regime, and she knows this. She is not unaware, moreover, that a war, even though victorious, would gravely threaten its success. Whatever one thinks privately of the principles, the spirit, and the methods which underlie this experiment, one is not able to predict with certainty that it will fail. Free bread for all is not yet a reality, but the general reduction of 30 per cent on all fixed prices, effective in a few days time, is one. Completely reliable witnesses attest this, and it would be unreasonable to doubt it. The Soviet Revolution is not accomplished, but it is under way, and the chief concern of the government in Moscow is to lead it to a successful conclusion. This preoccupation is so inconsistent with warlike intentions that it is not absurd to wonder if these exist.

The West is perhaps mistaken in imagining that, Hitler, once dead, is risen again. Though just as serious, the peril is not the same; a recourse to war was the supreme justification for naziism, but Marxist communism rests on what it believes is a necessary scientific law, the consequences of which are predictable with perfect infallibility. It believes that the communist experiment must inevitably lead Russia to a degree of prosperity and power which will make her the center of the world, while the capitalist countries, though outwardly healthy, will crumble away, destroying themselves. It is irrelevant that this pseudo-science of good and evil is only a faith; the important thing is to know that it exists, because it is this which forbids us to dismiss the appeal of the Soviets to peace as a sham. On the contrary, war is so manifestly the worst danger for their enterprise that they are not able to believe that the capitalist regimes don't desire it. For the Soviets do not doubt that, given fifty years of peace, communism will be master of the world; and that those who allowed them to have peace would then be lost. Peace with her adversaries seems to Moscow the surest way of getting rid of them.

So much for the Marxist faith—their "sense of history." Certainly one is able to hasten the inevitable. The Soviets are active in spreading communism everywhere abroad. The Party would not devote itself to the intense pacifist propaganda which it leads in every country if the actuality of a war, even though victorious, did not appear so menacing to the success of the Marxist Revolution; and, since the Soviets are not able to believe that their opponents are so blind as not

to be able to see this truth, every pact concluded to dissuade them from launching a war which they dread obviously appears to them as preparation for an attack upon them. From their own point of view, to announce that, in the event of armed conflict, one is already committed to the camp of their enemies is a first act of aggression.

And why, it might be said, should we reason from their viewpoint? The answer is: that we may be better able to reason from our own. It is not useless to understand the opponent if we wish to avoid choosing terms of defense which, far from being effective, run the risk of increasing the danger. The U.N. Charter attaches great importance to what it called—in the good days of the San Francisco conference—"zones of tension." To ease tension is always difficult, but perhaps we can avoid creating more than is really necessary. To let it be known that we anticipate war with a certain power, before we even possess the means of self-defense, is an aggravation of tension.

AMERICAN ATTITUDES

If it is not certain that the Soviets meditate aggression, it is quite certain that the United States are preparing none. At the summit of wealth and power, their only wish would be to enjoy their well-earned goods in peace without having on their hands those world responsibilities whose burden oppresses even them. History, the taste for liberty, feelings of affection and gratitude all bind us to this great country to whom we owe so much; but must we automatically join them in the event of war?

This very question aroused the indignation of some American patriots recently, but within the same circle which used to castigate the allied cause almost daily between 1939 and Pearl Harbor, in order to justify American neutrality. To recall their remarks of that time would be rubbing old sores, but at least we may remember how public opinion in the United States repudiated the notion that America ought to enter the war on the side of England and France—until Japan drove her into that position, without bothering to consult her.

The feelings which are best understood are those we remember having experienced. A little late, but still in time, the American army came to our aid during the First World War. In 1939 the French saw so clearly that the new war was only the old one begun again that they did not doubt for one moment that the American soldiers would soon be fighting at their side. As it turned out, we were no longer there when they finally arrived. But have we ever doubted America's friendship? Do we feel the least reproach for them today? We knew from the start that our war was also their war, as the sequel has plainly shown them on other grounds, and we can regret that they did not see it sooner; but that, after all, was their business, and we have never denied that the United States were free to stay neutral until the day when it suited them to fight, even supposing this day might never dawn. Should it be impossible for our American friends to imagine themselves in our position today and to consider the possibility that the French people, if confronted with the prospect of a conflict with a third power, might have the same feelings as they did in 1940?

POSSIBILITY OF WAR OUTSIDE EUROPE

Evidently they do not find this a parallel case. No people likes to fight alone, especially for a common cause, but we have already done so twice, and that is precisely why it is excusable for us to hesitate before the prospect of a new conflict. The United States understands these objections so well that they have signed the Atlantic Pact in order to meet them, but events develop swiftly and the situation has already changed since the ratification. What many congressmen then dreaded was the idea of committing themselves in advance to intervene on our side in a war which they thought would begin with a Russian aggression against the disarmed nations of Western Europe. It is clear that in such a case we would not have the choice between peace and war and that the United States would; but one begins to ask oneself if it is inconceivable that the conflict may erupt outside Europe and as a direct issue between two giants whose interests and ideologies are so violently at odds. Some American observers are already doubting whether a third world war must be necessarily European, or even Atlantic. Displeasing as it may be to our friends, the idea begins to take shape, and if it should be confirmed by future events, we must recognize that the pact would then operate in circumstances the reverse of those originally anticipated. It would be the USA which would no longer have any choice between peace and war, and Europe which would preserve the right to reflect.

FRENCH HESITANCY TO RISK TOTAL SACRIFICE UNLESS HER NATIONAL INTEGRITY IS ENDANGERED

It is true that we are being helped, succored, and armed. These good deeds, in which generosity vies with perspicacity, impose an immense debt of gratitude on us, but those to whom we owe this debt are the last to desire that gratitude should degenerate into servitude. When General de Gaulle had the courage to uphold the French point of view against proposals which seemed to him inadmissible, an American paper represented him as gnashing at the hand of a sorrowful Uncle Sam, above the caption: "He bites the hand that feeds him." But this is not our style, and, besides, we know that the hand which feeds us does not propose to keep us on a leash. Frenchmen ask no more. There is no question about their feelings or their preferences; the point at issue is whether a people can be bound in conscience, for any reason whatever, to plunge its body and soul into a war which will set the final seal on its ruin, unless it is a case where its national integrity is directly imperiled. In that event, it is to everybody's interest that we should be able to compel respect for our frontiers; but it is not obvious that anyone will derive any appreciable advantage from a total sacrifice which, on this occasion, will be beyond any imaginable repair. We are ready to make it if it is necessary, but not to rush into it.

UNITED NATIONS ATOMIC ENERGY NEWS

Francis W. Carpenter

Mr. Carpenter, who reports the activities of the United Nations Atomic Energy Commission for the Bulletin, is a member of the staff of the Associated Press. He has covered the work of the UNAEC since its first meeting in June 1946.

UNITED Nations Secretary-General Trygve Lie called for a new attempt to make progress on setting up world atomic controls in a ten-point peace program sent to the delegations of fifty-nine United Nations members on June 6.

Lie's point relating to atomic energy control is Number 2 on his ten-point program, but actually he rates it Number 1 in importance. The Number 1 point is a proposal for periodic meetings of the Security Council which would, among other things, consider some of the other proposals in the memorandum. A periodic meeting is a high-level session attended by Foreign Ministers or chiefs of state. The Council has not held such a meeting in its four-year career.

The Secretary-General made public his memorandum on June 6, 1950, with a letter to each delegation serving notice that he might bring the memorandum to the Security Council or the General Assembly at any time.

The atomic stalemate here has continued for months. There have been no worth-while developments on atomic energy in months and nothing of any consequence since January 19, when Soviet Deputy Foreign Minister Jakob A. Malik walked out of the six-power secret talks because the Nationalist Chinese delegate was not ousted.

During the spring Lie drew up his memorandum. He took it to Washington, London, Paris, and Moscow and personally handed it to heads of the governments of the four great powers. He won't talk about their reactions, but he noted in the June 6 letter to the delegations that he drew from his conversations with these governmental heads "a firm conviction that the United Nations remain a primary factor in the foreign policy of each of these governments and that the reopening of genuine negotiations on certain of the outstanding issues may be possible."

Lie has refused to say just which issues may be reopened, and the situation was at a standstill in mid-June while the governments considered his memorandum.

Point 2 in the proposals in Lie's memorandum, which contains the reference to atomic control, follows:

"2. A new attempt to make progress toward establishing an international control system for atomic energy that will be effective in preventing its use for war and promoting its use for peaceful purposes.

"We cannot hope for any quick or easy solution of this most difficult problem of atomic energy control. The only way to find out what is possible is to resume negotiations in line with the directive of the General Assembly last fall to 'explore all possible avenues and examine all concrete suggestions with a view to determining what might lead to an agreement.' Various suggestions for finding a basis for a fresh approach have been put forward. One possibility would be for the Security Council to instruct the Secretary-General to call a conference of scientists whose discussions might provide a reservoir of new ideas on the control of weapons of mass destruction and the promotion of peaceful uses of atomic energy that could thereafter be explored in the United Nations Atomic Energy Commission. Or, it may be that an interim agreement could be worked out that would at least be some improvement on the present situation of an unlimited atomic arms race, even though it did not afford full security. There are other possibilities for providing the basis for a new start; every possibility should be explored."

Lie held a press conference June 8, 1950, and he touched briefly on the point of a scientific conference. Here is the verbatim extract on that point:

"Question: You mentioned two possible ways [in the memorandum] of reopening negotiations on atomic energy. Would you care to expand on that?

"Secretary-General: I am sorry, but I cannot. That is a matter for the governments to discuss among themselves.

"Question: The calling of a meeting of atomic scientists could be done here at the United Nations, could it not?

"Secretary-General: Yes.

"Question: Have you any idea of that?

"Secretary-General: I do not know the reaction of the members about it."

On May 26, at his first press conference in Lake Success, after his swing around the four capitals, Lie said he had been on an exploring mission. He said he had not been negotiating and that the world would have to wait two or three months to see any results.

In his June 6 letter to delegates, Lie called attention to the appeal circulated on April 20, 1950, by the International Committee of the Red Cross[1] to the High Contracting Parties to the Geneva Conventions for the Protection of Victims of War, to do everything in their power to reach agreements on the prohibition of the atomic bomb and "blind" weapons generally. There has been no further comment in the U.N. on this appeal.

The U.N. received, without comment, news reports from Copenhagen that Professor Niels Bohr, noted Danish scientist, had written an open letter[2] to the U.N. appealing for world cooperation in the field of atomic energy with a free exchange of information.

U.N. officials said the letter was from an individual. They said they deal only with governments and they did not expect an official answer from the U.N. to this letter.

[1] Printed on page 223 of this issue.
[2] Printed on page 213 of this issue.

THE SOCIAL IMPLICATIONS OF SCIENCE

Kirtley F. Mather

The author of the following article is Professor of Geology at Harvard University and President-elect of the American Association for the Advancement of Science.

WE LIVE in a rapidly changing world. In the Middle Ages men considered the world stable and changeless, largely because their ways of living were much the same in old age as in youth, in one generation as in another.

Today, everybody is aware of change. The contrast between the ways of living at this mid-point of the twentieth century and at its beginning is vividly recorded in the mind of every elderly person and reported in vigorous words to every youngster. Even so, the consequences of the application to everyday life of the results of scientific research through technologic development are by no means as well understood and as widely known as they ought to be.

SCIENCE ACCELERATES THE RATE OF CHANGE

Take the relations between people in different localities as an example. There have always been three means of overcoming distance: travel technology, transport technology, and the technology of communication. For thousands of years, prior to the nineteenth century, these depended upon horses and camels on land, galleys and sailing vessels on water.

As late as 1834, Sir Robert Peel, called posthaste from Rome to London by a cabinet crisis, took thirteen days for the journey — precisely the time allowed for a Roman official eighteen hundred years ago. Today anyone can travel between those two capital cities in two days by rail and cross-channel steamer, in six hours or less by airplane. The remarkable decrease in travel time has made it economical to carry on many kinds of industrial and trading operations at great distances.

Transport technology has similarly been accelerated. Here the expense of shipping plays a role almost as basic as the speed of movement. In fact, it is the shipping cost that determines how far away from each other two cities can be and still find it advantageous to exchange products. The cost of transporting freight over long distances has been affected somewhat less drastically by modern technology than has been the speed of personal travel. Rail freight costs much less than wagon transport, but air freight costs are much higher than rail.

Communications technology has made the most spectacular progress of the three means of overcoming distance, and most of its progress has taken place in the last thirty years. Electrical communication is literally on the wings of light. Distance has been practically annihilated. But it was not until 1866 that the first successful trans-Atlantic cable was in operation, and not until 1901 was a wireless signal flashed between America and Europe. The first long-distance telephone conversation across the United States from coast to coast took place in 1915, the same year in which spoken words were first successfully transmitted by radiotelephone across the Atlantic. Today, voice communication is available between almost all cities and towns everywhere in the world. The three components of economic distance have shrunk so rapidly in the twentieth century that we are now in an era of planetary economy.

INCREASED DEPENDENCE UPON NATURAL RESOURCES

Modern technology depends upon the mineral and agricultural resources of the earth, just as truly as it depends upon the ingenuity, skill, and industry of men. The machinery and mechanical devices of our day call for a constant supply of raw materials. Each new advance in technology creates new needs for minerals and agricultural products.

Modern man is even more dependent upon the natural resources to be found in and on the outer shell of the earth than were his ancestors in pre-scientific ages. The world as a whole has consumed more of its mineral stores since 1900 than in all the previous history of mankind. Iron ore was being mined in the United States at annual rates of only about sixty million tons in the early nineteen twenties, whereas more than one hundred million tons have been mined each year since 1942.

The increase in energy requirements, as people take advantage of the contributions of science and technology to human comfort and efficiency, is especially noteworthy. Almost all of the swiftly operating, labor-saving machinery of our day is power-driven. Science has revolutionized society by discovering new sources of energy and harnessing them to do the work that men want done. The important, fundamental sources of energy are now coal, petroleum, natural gas, and water power.

The annual consumption of energy from these sources in the United States rose from 71 million Btu per capita in 1889 to 194 million Btu per capita in 1940. In 1940, 52.7 per cent of that energy was derived from coal, 43.9 per cent from petroleum and natural gas, and 3.4 per cent from water power. Cut off the supply of mineral fuels and most of us would have to revert promptly to the horse-and-buggy ways of a century ago.

Consider, too, the effects of farm mechanization upon our food supply. In Britain in the late nineteen thirties only 20 per cent of the draught power expended in cultivating the land was mechanical; in 1947 so many tractors had replaced horses that nearly 56 per cent of the draught power was derived ultimately from the mineral fuels. A large part of the increase in food per man-hour of labor was due to this mechanization of the farms, a process

which is going rapidly forward in many parts of the earth.

Fundamental in any inquiry concerning the impact of science upon modern life is the study of the changing energy requirements of technologically progressing man and the sources available today and tomorrow from which the needed energy may be derived. Any program for the improvement of conditions in the underdeveloped areas of the earth or the industrialization of agrarian regions must start with plans for discovery and utilization of the energy resources upon which man is absolutely dependent.

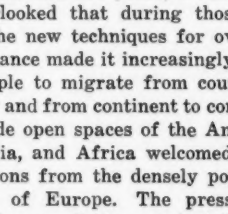
RAPID INCREASE IN POPULATION

The increased dependence of modern man upon the natural resources of the earth becomes even more significant as we note the phenomenal expansion of the human family since the impact of science became a factor of great importance in the life of man. During the one hundred years between 1650 and 1750, the world population expanded from about 545 million to about 728 million, an average annual growth of only 0.29 per cent. In the next fifty years, to 1800, during which the Industrial Revolution began to affect Europe and North America, the world population increased to about 906 million, an average annual growth of 0.44 per cent. By 1850 the population had reached approximately 1,171 million, with an average annual growth of 0.51 per cent during the first half of the nineteenth century. Then, as the effects of science and technology became more impressive and more widespread, the human family expanded still more rapidy, increasing in number at an average annual rate of 0.63 per cent throughout the second half of that century to reach a total of about 1,608 million in 1900. During the first half of the twentieth century, the rate of increase has been even greater, such that the present population of the earth is now estimated at approximately 2,300 million, roughly twice what it was a hundred years ago. If the average annual growth rate of the last few decades—0.75 per cent—should continue in the future, it would result in a doubling of the population every ninety-two years.

The extraordinary contrast between the rate of increase of the world population during the past hundred years and that displayed in preceding centuries is attributable to the impact of science upon human affairs. Marvelous advances in the medical sciences, new techniques and materials for maintaining good health, availability of essential equipment for sanitation and protection from infectious disease, better nutrition made possible by transportation of foods over long distances, improved living habits acquired as a result of the dissemination of knowledge gained through scientific research, all have been involved in producing the observed results. In consequence, the average span of life has been greatly lengthened and death rates have been astonishingly lowered in every technologically advanced community in the world.

In the Netherlands, for example, newborn baby boys will, on the average, live to an age of at least 65 years, whereas fifty years ago they would have had a life expectancy of only about 47 years. In the United States the annual death rate per thousand has fallen from more than 17 in 1900 to approximately 10 at the present time.

Although the factors mentioned in the foregoing paragraph were undoubtedly of paramount importance in the remarkable increase of the world population in the last 150 years, it should not be overlooked that during those very years the new techniques for overcoming distance made it increasingly easier for people to migrate from country to country and from continent to continent. The wide open spaces of the Americas, Australia, and Africa welcomed scores of millions from the densely populated regions of Europe. The pressure of expanding populations against the limitations of subsistence factors, established by the use then being made of



the natural resources in the environment, was thus relieved. Science and technology leveled the physical barriers. Mankind responded as never before to the age-old directive: "Be fruitful, multiply, and spread over the face of the earth."

But all that has now been changed. Since the beginning of the century, the previously vacant spaces of the habitable portion of the earth have been largely filled. Political barriers have been erected to prevent free migration. Our world is rapidly becoming a somewhat crowded neighborhood in which the ingenuity of science will be strained to find adequate means of subsistence for all the members of the human family.

CENTRALIZATION OF POWER

It is against the background of such facts as have just been sketched that the social implications of science must be examined. Especially in this time of drastic change, it is imperative that men of intelligence and goodwill give careful consideration to the social trends resulting in whole or in part from the impact of science. It would appear that in the long history of geologic life development, man is the first creature possessing the ability to determine his own destiny. The attitudes developed among men and the decisions made in these years may well shape the course of human history for many generations to come.

Many important results of the impact of science and technology upon human society are apparent. Without attempting to arrange them in any order of pre-eminence, let us begin with the trend toward centralization of power in the hands of a small minority of citizens within each nation as it attains technological maturity.

Power may be concentrated in the hands of a few people as a result either of economic or of political controls. Both have been profoundly influenced by the application of the results of scientific research.

One of the most significant effects of science upon the economic structure is displayed in the shift from self-employment to working for hire. Whereas a century and a half ago, no nation was composed predominantly of employees, today each of the highly industrialized nations is a nation of employees. Three-fifths of all the income received by individuals in the United States is in the form of wages. The rise of the corporation and the trade union, both of which are new types of organization, is a direct consequence of the application of science to industry. Both have now become powerful organizations with tremendous potentialities for both good and harm.

Although science has been transforming many a country into a nation of employees, it has not been building a proletariat. The trend is always away from unskilled manual labor to jobs requiring skill. Wherever industry based on science develops, a middle class appears and rapidly expands. Significantly enough, this is the most fertile source of radical ideas and pioneer leadership.

The trend toward concentration is reinforced by the need for scientific research. Both "pure" and "applied" research must go forward, whether one is primarily concerned with competition between rival corporations or with im-

proving the general welfare of one's fellow-men, and fortunately the two objectives are by no means incompatible. But the cost of scientific research inevitably mounts; the equipment is increasingly expensive; and large teams of workers must be organized for collective attacks upon major problems. Only those able to expend considerable sums of money can direct research. Quite naturally, they seek to control through patent laws the fruits of their own research. Logical, also, is the establishment of interlocking directorates among industrial, commercial, and financial corporations.

In consequence of this trend toward concentration of economic power, it becomes increasingly necessary for society to protect the interests of all its members through organized political controls. In every land, the responsibility of governments for the welfare of citizens is now being recognized. The methods used are highly diversified, and the objective scientist is fully justified in asserting that to date no nation has solved the baffling problems of modern political science with complete success. Science makes men more efficient and may make life more comfortable; it certainly does not make it any easier to live.

This is all the more apparent when we raise our sights from the trend toward concentration of power within a nation to the similar trend discernible among sovereign states. Imperialistic ambitions have been an influential if not a determining factor in the formulation of foreign policy for states and nations since the dawn of human history, but the impact of science has had far-reaching consequences upon the rise and decline of empires. The application of science makes necessary an ever lengthening list of raw materials as the basis for the economy. These raw materials, whether agricultural in nature or derived from mineral deposits, are unevenly distributed. Only the largest of the continents covers a sufficient variety of geologic structures and embraces enough different climatic zones to supply the needs of modern industry.

It was therefore an inevitable consequence of the growth of science that in the nineteenth century every aspiring nation should seek to make itself self-sufficient through imperial expansion. The demands for both raw materials and markets were insatiable, and these seemed best guaranteed by political ownership. Industrial strength has conferred political power, in so far as it is equated with military power, upon any state whose citizens have become technologically efficient. Thus the urge toward imperialism, stimulated by scientific progress, is implemented by the results of that progress.

Here also, however, the universal principle of change is operating. The evolution of the British Empire into a Commonwealth of interdependent autonomous nations is more than a mere symbol of what is happening. Throughout the world there is a surging desire to take more complete advantage of modern science. Ideas are the lightest baggage for distribution. Atoms and electrons obey the laws of nature without reference to the laws of political subdivisions. No nation nor group of people can long maintain a monopoly of knowledge. The desire to determine one's own destiny seems to be an ineradicable element of human nature. The latest results of technologic advances suggest the future decentralization and equalization of power rather than its further concentration.

Science has so increased man's efficiency in the dread art of killing men and destroying property that all informed persons are now aware of the utter futility of providing any adequate defense against attack. It cannot be said too often nor too loudly that, thanks to science and technology, no nation can emerge from World War III with anything approximating worth-while victory. Every competent scientist would affirm that some other way than that of warfare must be found to solve the problems of international relations.

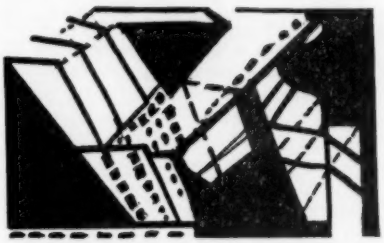
INESCAPABLE INTERDEPENDENCE

The directive for the other way is even now being discovered by the intelligence of science. Every man and every nation is inescapably dependent upon other men and other nations. Only through well-organized, collective activity can men use effectively the resources of the earth. That dictum is rather well understood as it pertains to the domestic economy of many nations. It is not yet widely acknowledged as applicable to the relations between nations.

No nation can hope to draw adequate amounts of all the materials essential to modern life from within its own borders. Each nation is a "have-not" nation with respect to some of the natural resources imperatively needed.

The metallic ores, the non-metallic deposits of economic value, and the mineral fuels that are the basic requisites for modern civilization occur under certain well-defined geological conditions. Their distribution is "spotty" but by no means haphazard or unpredictable.

Nature seems to have played a strange trick, for example, by making tin ores scarce in the highly industrialized regions where the tin can is an essential item and tin must be used in the alloys for the bearings of high-speed machinery. There are almost no ores of tin in North America; the puny deposits of that metal in Europe meet only 5 per cent of the needs of Europeans.



Similarly, because of their geological relationships, ores of nickel and uranium are found in only a few rare localities in three or four of the six continents. To a slightly less degree, the ores of antimony, vanadium, and chromium are also scattered sparsely throughout the earth.

The Soviet Union is the largest compact political unit of the world today and is the only nation for which the geologist can hold out any hope of self-sufficiency in regard to mineral resources. For a score of years that has been one of the aims of its government; the search for mineral deposits that would meet that nation's deficiencies has been prosecuted with high intelligence and great industry. Even so, at last reports, the USSR was still seriously deficient in many minerals, such as nickel, tungsten, tin, vanadium, sulphur, antimony, and mercury. Further geologic exploration and prospecting may reveal adequate supplies of some of these, but the chances are not favorable that all will be found in amounts great enough to meet the increasing needs of the nation's rapidly expanding industries.

The United States is fourth among the nations when ranked according to area, but foremost both in the production and consumption of mineral wealth. Since it is one of the most fortunate of nations because of its wide coverage of diversified geologic structures and its favorable relation to climatic zones, it is not surprising that many of its citizens have entertained the idea of building a fence around their country, organizing their economy on a self-sufficient basis, and letting the rest of the world go hang. It happens, however,

that the United States is inescapably dependent upon other nations for several essential raw materials. American manufacturers must import nickel, tin, antimony, chromium, and platinum. Moreover, American dependence upon foreign sources of mineral wealth will almost certainly increase during the next few decades. Scientific research has frequently resulted in a new demand for some relatively rare mineral or metallic ore, often available only in a foreign land, and that pattern of the past is most likely to be repeated. Even more certain is the future exhaustion of non-renewable resources, such as petroleum, which are now being exploited.

A dozen years hence it is more likely that the United States will be filling the gap between its consumption and production of petroleum products by importing oil from South America and the Middle East than by the more expensive process of manufacturing the required products from coal or oil shale. Iron is probably next in line. Before the end of the century the extensive reserves of rich iron ore in Cuba, Brazil, and Canada will begin to replace the dwindling stores of high-grade ore in the United States in spite of the presence there of a vast reserve of low-grade ore. In both instances, it will be a matter of relative costs. The greater expense of using inherently costly processes of chemical alteration will be balanced against the cost of transportation from foreign sources.

It is now evident that no country can hope to escape the bonds of interdependence forged for mankind during the geologic history of the earth. The techniques of discovering and utilizing the resources demanded in an age of science are now fairly well known. The next item on the agenda of civilization is the invention and practice of satisfactory procedures for making them and their products available to all. Fundamental to the consideration of these procedures is this geologic fact: the earth is far better adapted for occupation by men organized on a world-wide scale, with maximum opportunity for free exchange of raw materials and finished products, ideas, and information, the world around, than for occupation by men who insist upon building barriers between regions even so inclusive as a large nation or an entire continent.

SOURCES OF ENERGY

This fact is peculiarly important as we turn next to an inquiry concerning the social implications of those aspects of modern science that deal with the energy resources of the earth. Here, again, the pattern of progress emphasizes the interdependence of men and nations.

Nearly all of the major coal fields of the world are in highly industrialized regions, possessed by nations that are, or recently have been, the most powerful of the nations of the earth. Indeed, there is much truth in the assertion that Great Britain, France, Germany, and the United States rose to positions of dominance during the nineteenth century *because* each had extensive coal resources which could be utilized when coal was the pre-eminent source of mechanical power.

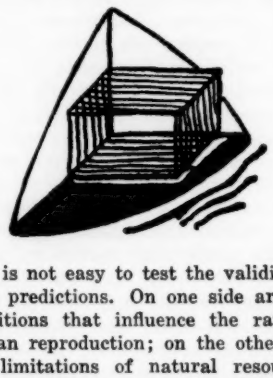
However, since the beginning of the twentieth century, and especially in the last twenty-five years, petroleum and natural gas have been increasingly used as a source of energy. The United States and the Soviet Union are fortunate in possessing both major oil fields and major coal fields. But nearly all of the other important oil fields of the world are in countries not yet industrialized, and nearly all of the other highly industrialized nations must import petroleum.

At the present time, hydro-electric energy is being used in increasing amounts, and this trend is certain to continue. The geographic distribution of the major sources of hydro-electricity bears much the same relation to industrialized and less-developed countries as that of the oil fields. Africa, for example, has far more potential water power than North America; the Andean republics of South America far more than the countries of Western Europe.

Moreover, many hydro-electric developments must be international projects. Perhaps such experiences will provide education whereby men will learn that the only way to profit fully from science is through friendly collaboration and sharing, even across the boundary lines drawn on maps.

POTENTIAL ABUNDANCE FOR ALL PEOPLE

Such an attitude could scarcely be expected if the resources were inadequate to provide the material basis for a good life for all. Focusing attention upon the unprecedented increase in the earth's population, many persons now predict that the resources of the earth will inevitably prove insufficient. The shadow of Malthus once more darkens the prospect for tomorrow.



It is not easy to test the validity of such predictions. On one side are the conditions that influence the rate of human reproduction; on the other are the limitations of natural resources. The basic query is: can the application of science to human behavior establish and maintain a satisfactory balance between supply and demand?

Certain recorded trends are available to form the basis of opinion. Consider first those that apply to the rates of increase in population. With the initial application of science to everyday life, there has invariably been a sharp increase in the rate of population growth. Death rates have rapidly declined; birth rates have remained the same or have decreased very slowly. In a few decades, however, the birth rate has also begun to fall rapidly, and the rate of population growth has levelled off toward a stable condition. The nations of Western and Northwestern Europe have already attained what seems to be nearly their all-time maximum of inhabitants. Other nations—the United States being one of them—are rapidly approaching a stable population. These are the regions that enjoy the highest standard of living of all communities. For them, the external restraints described by Malthus certainly do not apply.

In other regions, such as Southern and Southeastern Europe, India, China, Southeastern Asia, and Puerto Rico, the present productivity of the soil provides food enough to keep the masses from starving, but not enough to keep everyone well fed. Birth rates and death rates, both are high. The Malthusian principle seems to be valid. But these are the less developed regions of the earth where few of the inhabitants are taking full advantage of the opportunities that modern science can provide.

Among all the nations, the more complete the industrialization and the better the standard of living, the lower is the

birth rate. Similarly, the higher the percentage of illiterate folk within a nation, the higher is its birth rate. If one is interested in hastening the stabilization of population, the method to be followed is clearly evident: assist progress toward mechanization of industry, agriculture, and commerce, and help to reduce illiteracy.

Since 1900, the colored races have made considerable progress toward attaining the lower death rate of the white man. Progress toward attaining the white man's lower birth rate has been appreciable but much less rapid. Consequently, for the next few decades the colored peoples will increase in number more rapidly than the white, thus reversing the trend of the past century. Whereas in the eighteenth century the white peoples constituted only about 22 per cent of the world population, today they are approximately 35 per cent of the total. But the many factors that bear upon reproductivity seem to be essentially the same, regardless of the pigmentation of the skin. In time—three or four decades for some communities, six or eight for others—the balance between fertility and mortality among colored peoples will be similar to that among white people.

Projecting the curves of population growth from the first half of the twentieth century and applying the pattern of the white man to the future of the colored man, it would appear that the world population will become practically stable by the middle of the twenty-first century. The future population of the entire world might then be in the neighborhood of 3,500 million, certainly not more than 4,000 million.

That is not too many people for the earth to support. At the present time, in many parts of the world, agricultural methods are as archaic as an ox-cart would be in London. No advantage has been taken of the results of modern research concerning soil use. Only a small fraction of the world's farmers are applying the knowledge of modern agricultural procedures. If that knowledge could be spread, and if the better strains of plants and animals could be made available everywhere, the soil now under cultivation could provide a wholly satisfactory diet for nearly that number of persons.

Moreover, by no means all of the earth's potentially arable lands are now in use. There are many square miles of swamp that can be drained, even larger areas of arid land awaiting irrigation, and vast expanses of tropical jungle that can be put to valuable use. The task of the pioneer is more difficult today than it was, but it is not an impossible task. Significantly enough, the tasks ahead call for collective activity by large groups organized for technical operations and engineering feats on a grand scale.

Such operations call for continuing utilization of non-renewable metallic ores as well as a constant supply of energy. Actually, the problems that now seem most difficult are those of the distribution of food rather than its production. These, too, involve transport equipment which means more machinery and more energy.

Fortunately, the available reserves of metallic ores and mineral fuels throughout the world as a whole are now known to be hundreds if not thousands of times the recent annual extraction. Certain items are in relatively short supply, but substitutes for them are available. Even with the expectation that demands will increase greatly because of expanding industrialization, it would appear that nature's stored capital of mineral resources is adequate to meet human needs for many generations to come.

Nor do we need to worry about the more distant future when all the petroleum and coal, or all the iron and copper, have been extracted from the terrestrial storehouse. If we, in our generation, have learned how to synthesize gasoline from oil shale, extract magnesium from sea water, transform the nitrogen of the air into food for plants, release atomic energy by nuclear fission, surely those who come a thousand years hence will be able to solve the new problems of their day. Quite possibly, if we behave ourselves for the next twenty-five or fifty years, they will be our descendants, inheriting from us the spirit of scientific inquiry that has so

drastically changed our world from that of our grandparents. Our responsibility is for ourselves and the next generation or two.

Science and technology have charted the road to survival. It leads to wise adjustment between populations and available resources. Ours is an age of potential abundance, as well as inescapable interdependence. But no small group of nations can move forward along that road and leave the rest of the world behind. Either all of us gain lasting security as inhabitants of the earth, or we all go down together in a universal doomsday. That is the most basic of all the social implications of modern science.

THE LIFE OF THE INDIVIDUAL

That, also, brings our thoughts back to the individuals of whom the world society is composed. Human nature is such that men cannot be considered merely as statistical units in a scientific tabulation or as nothing more than cogs in a machine. The only truly effective managerial technology is that which emphasizes the unique value and inalienable prerogatives of each person in the group. The mechanical devices and the scientifically designed procedures that play so large a part in everyday life are exerting a profound effect not only upon the human body but also upon the human spirit.

With progress of technology, the capacities of vast numbers of human beings have been enormously heightened. Time is now available, as never before, for activities other than those connected with the grim business of getting a living. Endless new possibilities of cultural growth are now in view. The exigencies of life in a technologic environment have, moreover, certain desirable effects on human character. The experiences of men with machines make exacting demands upon the personal resources of precision and endurance, of skill and judgment, of persistence and decision.

All this puts increased emphasis upon the importance of education in preparing men for the new responsibilities and opportunities of our world. Not only must individuals learn special skills, but they must also develop the inner resources that are essential to really satisfactory use of hours of leisure. For large numbers of persons, the impact of science has greatly lengthened the years of preparation necessary before one may enter upon his life vocation and at the same time it has extended the years of healthy existence after one is "too old to work."

In the United States, for example, only 2 per cent of the population in 1850 were 65 years of age or older, whereas 5 per cent were in this age group in 1940, and, if present trends continue, this group will comprise 15 per cent of the total population in 1980. When one considers the responsibility for rendering the services essential to national prosperity, it is encouraging to note that those in the age group 20 to 64 inclusive have increased from only 45 per cent of the total population in

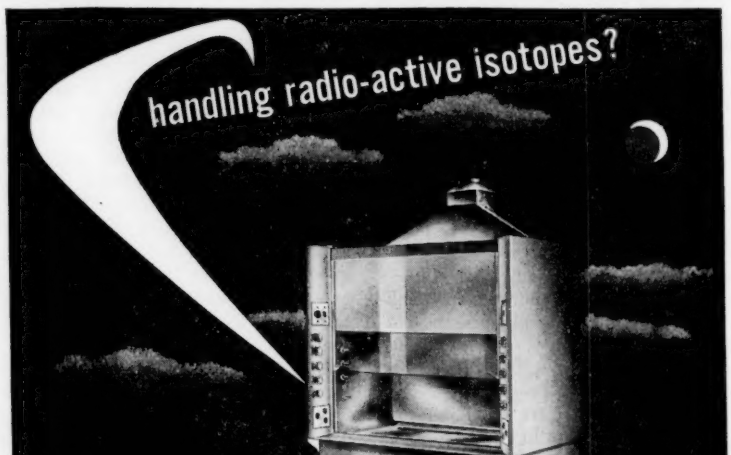
1850 to 58 per cent in 1940 and, if present trends continue, will comprise 61 per cent of the total in 1980. Obviously this provides sufficient manpower to do the nation's work, but, at the same time, it puts an increasingly heavy responsibility upon all citizens to provide both for the best possible education of youngsters and for the adequate support of the elderly.

Perhaps, however, the most important effect of participating in the technologic culture of an "Age of Science," and certainly the one that has the greatest bearing upon the mental and spiritual aspects of the life of the individual, is the new temper of respect for fact. Machines breed respect for the impersonal, neutral, and obdurate operations of the physical world. The achievements made possible by scientific methods of observation and analysis bring a new spirit into the life of man. Instead of depending upon beliefs and prejudices, modern man is making the final arbiter of judgment a set of facts, knowledge of which is available to all normally constituted individuals. There is still a lot of wishful thinking and much unquestioning acceptance of the pronouncements of those who influence public opinion, but the appeal to facts is a fairly common practice nowadays. The effective leader is one who does not order people around but who tells them why he believes they should do as he suggests.

This habit of acknowledging a neutral world of fact has been primarily responsible for the achievements of modern science. Each scientist has not only been permitted but encouraged to form and express his own independent judgment. When he has thought others were wrong, he has said so. By the same token, each has been ready to submit his own ideas to the judgment of his fellows. All have been confident that from the controversy a collective judgment generally acceptable to all would develop. Those who would restrict the free society within the fraternity of scientists, either through desire for national security or in an effort to make everybody conform to a "party line," should beware that in so doing they are likely to destroy the very spirit that makes progress possible.

The immediate future of mankind will be determined by something other than mere increase in knowledge. The life of the individual must be supported upon a tripod, the three legs of which may be called science, ethics, and art. These three elements of culture must be integrated if men are to take advantage of the possibilities for improvement afforded by any one of them. There are those who say that our difficulties arise because the natural sciences have advanced so much farther than the social sciences. Such critics of the contemporary scene are groping toward the truth, but they have not quite grasped it. The trouble really arises from the fact that the dynamic of goodwill is not adequate to direct beneficially the vast resources of intelligence that are at hand.

The most important social implication of science as it affects the personal life of each individual may well be found at this point. The ethical consciousness of each man must be greatly strengthened, renewed, and improved, if civilization is to be saved from catastrophe. The well-springs of goodwill lie deep within the spirit of man. Its sources are in the inner, private life of individuals, not in the outer, public world. Science discloses the imperative need; something that transcends science must assist men to respond to this challenge of our time.



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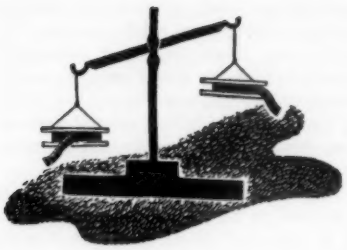

Niels Bohr

Professor Niels Bohr, the creator of the quantum theory of atomic structure, is a revered teacher of a generation of theoretical physicists, including many of those who played a leading part in the development of the atomic bomb. For many years, his Institute at Copenhagen has been the gathering place of physicists from all over the world. In 1943, he was brought over from German-occupied Denmark to help in the American atomic bomb project. As he reveals now, he had at that time not only given scientific advice, but had also been one of the first—if not the first—to present to the American political leadership an analysis of the political implications of the release of atomic energy. In his conversations with President Roosevelt, and memoranda which he directed to the President on July 3, 1944, and March 25, 1945, he outlined the international problems of control which the discovery of atomic energy is bound to raise, and has emphasized the impossibility of solving them except on the basis of whole-hearted cooperation and open exchange of ideas and information between all nations. These presentations had preceded the analogous but politically more concrete memoranda by Dr. Szilard in March 1945, and by the "Franck Committee" in June 1945, which have been previously reprinted in the Bulletin.[1]

Dr. Bohr has made no public statements on the political implications of atomic energy since 1945. If he now feels himself impelled to memoiralize to the United Nations on the necessity of returning to the prewar system of free exchange of ideas and information between nations, his argumentation commands attention, despite the momentarily unfavorable world-political climate. His central idea is that restoration of openness in the flow of ideas and information should be attempted as the first *(and, he hopes, decisive) step toward the re-establishment of international cooperation, rather than postponed until* after *the settlement of world-political controversies.*

I ADDRESS myself to the organization, founded for the purpose of furthering cooperation between nations on all problems of common concern, with some considerations regarding the adjustment of international relations required by modern development of science and technology. While this development holds out great promise for the improvement of human welfare, it also places formidable means of destruction in the hands of man, and has thus presented our whole civilization with a most serious challenge.

My association with the American-British atomic energy project during the war gave me the opportunity of submitting to the governments concerned views regarding the hopes and the dangers which the accomplishment of the project might imply as to the mutual relations between nations. While possibilities still existed of immediate results of the negotiations within the United Nations on an arrangement for the use of atomic energy guaranteeing common security, I have been reluctant to take part in the public debate on this question. In the present critical situation, however, I have felt that an account of my views and experiences may perhaps contribute to renewed discussion about these matters so deeply influencing international relationships.

In presenting views which, at an early stage, impressed themselves on a scientist who had the opportunity to follow developments at close hand, I am acting entirely on my own responsibility and without consulting the government of any country. The aim of the present account is to point to the unique opportunities for furthering understanding and cooperation between nations, created by the advance of science, and to stress that, despite previous disappointments, these opportunities still remain and that all hopes and all efforts must be centered on their realization.

[1] *Bulletin*, III (December 1947), 351-53, and *Bulletin*, I (May 1, 1946), 2-4, 16.

INTERNATIONAL COOPERATION A DECISIVE FACTOR IN PAST SCIENTIFIC ACHIEVEMENTS

For the modern rapid development of science and, in particular, for the adventurous exploration of the properties and structure of the atom, international cooperation of an unprecedented extension and intensity has been of decisive importance. The fruitfulness of the exchange of experiences and ideas between scientists from all parts of the world was a great source of encouragement to every participant and strengthened the hope that an ever closer contact between nations would enable them to work together on the progress of civilization in all its aspects.

Yet, no one confronted with the divergent cultural traditions and social organization of the various countries could fail to be deeply impressed by the difficulties in finding a common approach to many human problems. The growing tension preceding the Second World War accentuated these difficulties and created many barriers to free intercourse between nations. Nevertheless, international scientific cooperation continued as a decisive factor in the development which, shortly before the outbreak of the war, raised the prospect of releasing atomic energy on a vast scale.

The fear of being left behind was a strong incentive in various countries to explore, in secrecy, the possibilities of using such energy sources for military purposes. The joint American-British project remained unknown to me until, after my escape from occupied Denmark in the autumn of 1943, I came to England at the invitation of the British government. At that time I was taken into confidence about the great enterprise which had then reached an advanced stage.

Everyone associated with the atomic energy project was, of course, conscious of the serious problems which would confront humanity once the enterprise

was accomplished. Quite apart from the role atomic weapons might come to play in the war, it was clear that permanent grave dangers to world security would ensue unless measures to prevent abuse of the new formidable means of destruction could be universally agreed upon and carried out.

As regards this crucial problem, it appeared to me that the very necessity of a concerted effort to forestall such ominous threats to civilization would offer quite unique opportunities to bridge international divergencies. Above all, early consultations between the nations allied in the war about the best ways jointly to obtain future security might contribute decisively to that atmosphere of mutual confidence which would be essential for cooperation on the many other matters of common concern.

In the beginning of 1944, I was given the opportunity to bring such views to the attention of the American and British governments. It may be in the interest of international understanding to record some of the ideas which at that time were the object of serious deliberation. For this purpose, I quote from a memorandum which I submitted to President Roosevelt as a basis for a long conversation which he granted me in August 1944. Besides a survey of the scientific background for the atomic energy project, which is now public knowledge, this memorandum, dated July 3, 1944, contained the following passages regarding the political consequences which the accomplishment of the project might imply:

MEMORANDUM TO ROOSEVELT, JULY 1944

It certainly surpasses the imagination of anyone to survey the consequences of the project in years to come, where, in the long run, the enormous energy sources which will be available may be expected to revolutionize industry and transport. The fact of immediate preponderance is, however, that a weapon of an unparalleled power is being created which will completely change all future conditions of warfare.

Quite apart from the question of how soon the weapon will be ready for use and what role it may play in the present war, this situation raises a number of problems which call for most urgent attention. Unless, indeed, some agreement about the control of the use of the new active materials can be obtained in due time, any temporary advantage, however great, may be outweighed by a perpetual menace to human security.

Ever since the possibilities of releasing atomic energy on a vast scale came in sight, much thought has naturally been given to the question of control, but the further the exploration of the scientific problems concerned is proceeding, the clearer it becomes that no kind of customary measures will suffice for this purpose, and that the terrifying prospect of a future competition between nations about a weapon of such formidable character can only be avoided through a universal agreement in true confidence.

In this connection it is particularly significant that the enterprise, immense as it is, has still proved far smaller than might have been anticipated, and that the progress of the work has continually revealed new possibilities for facilitating the production of the active materials and of intensifying their effects.

The prevention of a competition prepared in secrecy will therefore demand such concessions regarding exchange of information and openness about industrial efforts, including military preparations, as would hardly be conceivable unless all partners were assured of a compensating guarantee of common security against dangers of unprecedented acuteness.

The establishment of effective control measures will of course involve intricate technical and administrative problems, but the main point of the argument is that the accomplishment of the project would not only seem to necessitate but should also, due to the urgency of mutual confidence, facilitate a new approach to the problems of international relationship.

The present moment where almost all nations are entangled in a deadly struggle for freedom and humanity might, at first sight, seem most unsuited for any committing arrangement concerning the project. Not only have the aggressive powers still great military strength, although their original plans of world domination have been frustrated and it seems certain that they must ultimately surrender, but even when this happens, the nations united against aggression may face grave causes of disagreement due to conflicting attitudes toward social and economic problems.

A closer consideration, however, would indicate that the potentialities of the project as a means of inspiring confidence under these very circumstances acquire real importance. Moreover, the present situation affords unique possibilities which might be forfeited by a postponement awaiting the further development of the war situation and the final completion of the new weapon....

In view of these eventualities the present situation appears to offer a most favorable opportunity for an early initiative from the side which by good fortune has achieved a lead in the efforts of mastering mighty forces of nature hitherto beyond human reach.

Without impeding the immediate military objectives, an initiative, aiming at forestalling a fateful competition, should serve to uproot any cause of distrust between the powers on whose harmonious collaboration the fate of coming generations will depend.

Indeed, it would appear that only when the question is raised among the united nations as to what concessions the various powers are prepared to make as their contribution to an adequate control arrangement, it will be possible for any one of the partners to assure himself of the sincerity of the intentions of the others.

Of course, the responsible statesmen alone can have insight as to the actual political possibilities. It would, however, seem most fortunate that the expectations for a future harmonious international cooperation, which have found unanimous expression from all sides within the united nations, so remarkably correspond to the unique opportunities which, unknown to the public, have been created by the advancement of science.

Many reasons, indeed, would seem to justify the conviction that an approach with the object of establishing common security from ominous menaces, without excluding any nation from participating in the promising industrial development which the accomplishment of the project entails, will be welcomed, and be met with loyal cooperation in the enforcement of the necessary far-reaching control measures.

It is in such respects that helpful support may perhaps be afforded by the world-wide scientific collaboration which for years has embodied such bright promises for common human striving. Personal connections between scientists of different nations might even offer means of establishing preliminary and unofficial contact.

It need hardly be added that any such remark or suggestion implies no underrating of the difficulty and delicacy of the steps to be taken by the statesmen in order to obtain an arrangement satisfactory to all concerned, but aims only at pointing to some aspects of the situation which might facilitate endeavors to turn the project to the lasting benefit of the common cause.

The secrecy regarding the project which prevented public knowledge and open discussion of a matter so profoundly affecting international affairs added, of course, to the complexity of the task of the statesmen. With full appreciation of the extraordinary character of the decisions which the proposed initiative involved, it still appeared to me that great opportunities would be lost unless the problems raised by the atomic development were incorporated into the plans of the allied nations for the postwar world.

This viewpoint was elaborated in a supplementary memorandum in which

the technical problem of control measures was further discussed. In particular, I attempted to stress that just the mutual openness, which now was obviously necessary for common security, would in itself promote international understanding and pave the way for enduring cooperation. This memorandum, dated March 24, 1945, contains, besides remarks which have no interest today, the following passages:

MEMORANDUM ON TECHNICAL PROBLEMS OF CONTROL, MARCH 1945

Above all, it should be appreciated that we are faced only with the beginning of a development and that, probably within the very near future, means will be found to simplify the methods of production of the active substances and intensify their effects to an extent which may permit any nation possessing great industrial resources to command powers of destruction surpassing all previous imagination.

Humanity will, therefore, be confronted with dangers of unprecedented character unless, in due time, measures can be taken to forestall a disastrous competition in such formidable armaments and to establish an international control of the manufacture and use of the powerful materials.

Any arrangement which can offer safety against secret preparations for the mastery of the new means of destruction would, as stressed in the memorandum, demand extraordinary measures. In fact, not only would universal access to full information about scientific discoveries be necessary, but every major technical enterprise, industrial as well as military, would have to be open to international control.

In this connection it is significant that the special character of the efforts which, irrespective of technical refinements, are required for the production of the active materials, and the peculiar conditions which govern their use as dangerous explosives, will greatly facilitate such control and should ensure its efficiency, provided only that the right of supervision is guaranteed.

Detailed proposals for the establishment of an effective control would have to be worked out with the assistance of scientists and technologists appointed by the governments concerned, and a standing expert committee, related to an international security organization, might be charged with keeping account of new scientific and technical developments and with recommending appropriate adjustments of the control measures.

On recommendations from the technical committee the organization would be able to judge the conditions under which industrial exploitation of atomic energy sources could be permitted with adequate safeguards to prevent any assembly of active material in an explosive state....

As argued in the memorandum, it would seem most fortunate that the measures demanded for coping with the new situation, brought about by the advance of science and confronting mankind at a crucial moment of world affairs, fit in so well with the expectations for future intimate international cooperation which have found unanimous expression from all sides within the nations united against aggression.

Moreover, the very novelty of the situation should offer a unique opportunity for appealing to an unprejudiced attitude, and it would even appear that an understanding about this vital matter might contribute most favorably toward the settlement of other problems where history and traditions have fostered divergent viewpoints.

With regard to such wider prospects, it would seem that the free access to information, necessary for common security, should have far-reaching effects in removing obstacles barring mutual knowledge about spiritual and material aspects of life in the various countries, without which, respect and goodwill between nations can hardly endure.

Participation in a development, largely initiated by international scientific collaboration and involving immense potentialities for human welfare, would also reinforce the intimate bonds which were created in the years before the war between scientists of different nations. In the present situation these bonds may prove especially helpful in connection with the deliberations of the respective governments and the establishment of the control....

In all the circumstances it would seem that an understanding could hardly fail to result, when the partners have had a respite in which to consider the consequences of a refusal to accept the invitation to cooperate, and to convince themselves of the advantages of an arrangement guaranteeing common security without excluding anyone from participation in the promising utilization of the new sources of material prosperity.

All such opportunities may, however, be forfeited if an initiative is not taken while the matter can be raised in a spirit of friendly advice. In fact, a postponement to await further developments might, especially if preparations for competitive efforts in the meantime have reached an advanced stage, give the approach the appearance of an attempt at coercion in which no great nation can be expected to acquiesce.

Indeed, it need hardly be stressed how fortunate in every respect it would be if, at the same time as the world learns of the formidable destructive power which has come into human hands, it could be told that the great scientific and technical advance has been helpful in creating a solid foundation for a future peaceful cooperation between nations.

Looking back on those days, I find it difficult to convey with sufficient vividness the fervent hopes that the progress of science might initiate a new era of harmonious cooperation between nations, and the anxieties lest any opportunity to promote such a development be forfeited.

Until the end of the war, I endeavored by every way open to a scientist to stress the importance of appreciating the full political implications of the project and to advocate that, before there could be any question of use of atomic weapons, international cooperation be initiated on the elimination of the new menaces to world security.

I left America in June 1945, before the final test of the atomic bomb, and remained in England, until the official announcement in August 1945 that the weapon had been used. Soon thereafter I returned to Denmark and have since had no connection with any secret, military or industrial, project in the field of atomic energy.

THE FAILURE OF THE POSTWAR EFFORTS AT COOPERATION

When the war ended and the great menaces of oppression to so many peoples had disappeared, an immense relief was felt all over the world. Nevertheless, the political situation was fraught with ominous forebodings. Divergencies in outlook between the victorious nations inevitably aggravated controversial matters arising in connection with peace settlements. Contrary to the hopes for future fruitful cooperation, expressed from all sides and embodied in the Charter of the United Nations, the lack of mutual confidence soon became evident.

The creation of new barriers restricting the free flow of information between countries further increased distrust and anxiety. In the field of science, especially in the domain of atomic physics, the continued secrecy and restrictions deemed necessary for security reasons hampered international cooperation to an extent which split the world community of scientists into separate camps.

Despite all attempts, the negotiations within the United Nations have so far failed in securing agreement regarding measures to eliminate the dangers of atomic armament. The sterility of these negotiations, perhaps more than anything else, made it evident that a constructive approach to such vital matters of common concern would require an atmosphere of great confidence.

Without free access to all information of importance for the interrelations between nations, a real improvement of world affairs seemed hardly imaginable. It is true that some degree of mutual openness was envisaged as an integral part of any international arrangement regarding atomic energy, but it grew

ever more apparent that, in order to pave the way for agreement about such arrangements, a decisive initial step toward openness had to be made.

THE IDEAL OF THE OPEN WORLD

The ideal of an open world, with common knowledge about social conditions and technical enterprises, including military preparations, in every country, might seem a far remote possibility in the prevailing world situation. Still, not only will such relationship between nations obviously be required for genuine cooperation toward the progress of civilization, but even a common declaration of adherence to such a course would create a most favorable background for concerted efforts to promote universal security. Moreover, it appeared to me that the countries which had pioneered in the new technical development and were, therefore, able to offer valuable information, might be in a special position to take the initiative by a direct proposal of full mutual openness.

I thought it appropriate to bring these views to the attention of the American Government without raising the delicate matter publicly. On visits to the United States in 1946 and in 1948 to take part in scientific conferences, I therefore availed myself of the opportunity to suggest such an initiative to American statesmen. Even if it involves repetition of arguments already presented, it may serve to give a clearer impression of the ideas under discussion on these occasions to quote a memorandum, dated May 17, 1948, submitted to the Secretary of State as a basis for conversations in Washington in June 1948:

PROPOSALS TO U.S. GOVERNMENT, JUNE 1948

The deep-rooted divergencies in attitudes to many aspects of human relationship which have grown out of social and political developments in the last decades, were bound to present a serious strain on international relations at the conclusion of the Second World War. While, during the war, the efforts in common defense largely distracted attention from such divergencies, it was clear that the realization of the hopes for wholehearted cooperation, expressed by all the nations united against aggression, would demand a radically new approach to international relations.

The necessity for a readjustment of such relations was even further accentuated by the great scientific and technical developments which hold out bright prospects for the promotion of human welfare, but, at the same time, have placed formidable means of destruction in the hands of man. Indeed, just as previous technical progress has led to the recognition of need for adjustments within civilized societies, many barriers between nations which hitherto were thought necessary for the defense of national interests now obviously stand in the way of common security.

The fact that this challenge to civilization presents the nations with a matter of the deepest common concern should offer a unique opportunity for seeking continued cooperation on vital problems. Even during the war it was felt that a favorable foundation for later developments might be created by an early initiative aimed at inviting confidence by making all partners aware of the actual situation which would have to be faced, and by assuring them of willingness to share in the far-reaching concessions as to accustomed national prerogatives which would be demanded from every side.

In the years which have passed since the war, the divergencies in outlook have manifested themselves ever more clearly, and a most desperate feature of the present situation is the extent to which the barring of intercourse has led to distortion of facts and motives, resulting in increasing distrust and suspicion between nations and even between groups within many nations. Under these circumstances the hopes embodied in the establishment of the United Nations Organization have met with repeated great disappointments. In particular, it has not been possible to obtain consent with respect to the control of atomic energy armaments.

In this situation, with deepening cleavage between nations and with spreading anxiety for the future, it would seem that the turning of the trend of events requires that a great issue be raised, suited to invoke the highest aspirations of mankind. Here it appears that the stand for an open world, with unhampered opportunities for common enlightenment and mutual understanding, must form the background for such an issue. Surely, respect and goodwill between nations cannot endure without free access to information about all aspects of life in every country.

Moreover, the promises and dangers involved in the technical advances have now most forcibly stressed the need for decisive steps toward openness as a primary condition for the progress and protection of civilization. The appreciation of this point, it is true, underlies the proposals to regulate cooperation in the development of the new resources, brought before the United Nations Atomic Energy Commission, but the very difficulty experienced in obtaining agreement under present world conditions would suggest the necessity of centering the issue more directly on the problem of openness.

Under the circumstances it would appear that most careful consideration should be given to the consequences which might ensue from an offer, extended at a well-timed occasion, of immediate measures toward openness on a mutual basis. Such measures should, in some suitable manner, grant access to information, of any kind desired, about conditions and developments in the various countries and thereby allow the partners to form proper judgments of the actual situation confronting them.

An initiative along such lines might seem beyond the scope of conventional diplomatic caution; yet it must be viewed against the background that, if the proposals should meet with consent, a radical improvement of world affairs would have been brought about, with entirely new opportunities for confident cooperation and for agreement on effective measures to eliminate common dangers.

Nor should the difficulties in obtaining consent be an argument against taking the initiative since, irrespective of the immediate response, the very existence of an offer of the kind in question should deeply affect the situation in a most promising direction. In fact, a demonstration would have been given to the world of preparedness to live together with all others under conditions where mutual relationships and common destiny would be shaped only by honest conviction and good example.

Such a stand would, more than anything else, appeal to people all over the world, fighting for fundamental human rights, and would greatly strengthen the moral position of all supporters of genuine international cooperation. At the same time, those reluctant to enter on the course proposed would have been brought into a position difficult to maintain since such opposition would amount to a confession of lack of confidence in the strength of their own cause when laid open to the world.

Altogether, it would appear that, by making the demand for openness a paramount issue, new possibilities would be created, which, if purposefully pursued, might bring humanity a long way forward toward the realization of that cooperation in the progress of civilization which is more urgent and, notwithstanding present obstacles, may still be within nearer reach than ever before.

The consideration in this memorandum may appear utopian, and the difficulties and complications of non-conventional procedures may explain the hesitations of governments to demonstrate adherence to the course of full mutual openness. Nevertheless, such a course should be in the deepest interest of all nations, irrespective of differences in social and economic organization, and the hopes and aspirations expressed in the memorandum are no doubt shared by people all over the world.

While the present account may perhaps add to the general recognition of the difficulties experienced by every nation confronted by the coincidence of a great upheaval in world affairs with a veritable revolution in technical resources, it is in no way meant to imply that the situation does not still offer unique opportunities. On the contrary, the aim is to point to the necessity of

reconsidering, from every side, the ways and means of cooperating to avoid mortal menaces to civilization and to turn the progress of science to lasting benefit of all humanity.

UNPREJUDICED ATTITUDE NEEDED TOWARD QUESTIONS OF INTERNATIONAL RELATIONS

Within the last years, world-wide political developments have increased the tension between nations, and the sight of great countries competing in the possession of means of annihilating populations of large areas and even making parts of the earth temporarily uninhabitable has caused widespread confusion and alarm.

As humanity is unlikely to renounce the prospects of improving the material conditions for civilization by atomic energy sources, a radical adjustment of international relationship is evidently indispensable if civilization is to survive. Here, the crucial point is that any guarantee that the progress of science will be used only for the benefit of mankind presupposes the same attitude as is required for cooperation between nations in all domains of culture.

Also in other fields of science recent progress has confronted us with a situation similar to that created by the development of atomic physics. Even medical science, which holds out such bright promises for the health of people all over the world, has created means of extinguishing life which imply grave menaces to civilization unless universal confidence and responsibility can be firmly established.

The situation calls for a completely unprejudiced attitude toward all questions of international relations. Indeed, proper appreciation of the duties and responsibilities implied in world citizenship is in our time more necessary than ever before. On the one hand, the progress of science and technology has tied the fate of all nations inseparably together; on the other hand, it is on a most varied cultural background that vigorous endeavors for national self-assertion and social development are being made in the different parts of our globe.

FREE ACCESS TO INFORMATION THE BASIS FOR INTERNATIONAL COOPERATION

An open world where each nation can assert itself solely by the extent to which it can contribute to the common culture and is able to help others with experience and resources must be the goal to be put above everything else. Example in such respects can be effective only if isolation is abandoned and free discussion of cultural and social developments permitted across all boundaries.

Within any community it is possible for the citizens to strive together for common welfare only on a basis of public knowledge of the general conditions in the country. Likewise, real cooperation between nations on problems of common concern presupposes free access to all information of importance for their relations. Any argument for upholding barriers for information and intercourse, based on concern for national ideals or interests, must be weighed against the beneficial effects of common enlightenment and the relieved tension resulting from openness.

In the search for a harmonious relationship between the life of the individual and the organization of the community, there have always been and will ever remain many problems to ponder and principles for which to strive. However, to make it possible for nations to benefit from the experience of others and to avoid mutual misunderstanding of intentions, free access to information and unhampered opportunity for exchange of ideas must be granted everywhere.

In this connection it has to be recognized that abolition of barriers would imply greater modifications in administrative practices in countries where new social structures are being built up in temporary seclusion than in countries with long traditions in governmental organization and international contacts. Common readiness to assist all peoples in overcoming difficulties of such kind is, therefore, most urgently required.

The development of technology has now reached a stage where the facilities for communication have provided the means for making all mankind a cooperating unit, and where, at the same time, fatal consequences to civilization may ensue unless international divergencies are considered as issues to be settled by consultation based on free access to all relevant information.

The very fact that knowledge is in itself the basis for civilization points directly to openness as the way to overcome the present crisis. Whatever judicial and administrative international authorities may eventually have to be created in order to stabilize world affairs, it must be realized that full mutual openness, only, can effectively promote confidence and guarantee common security.

Any widening of the borders of our knowledge imposes an increased respon-

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Editorial: Atomic Weapons and the Korean War

(Continued from page 194)

come if we want to see on our side not only the rich city dwellers and feudal landlords, or the majority of peaceful, submissive peasants, but also the active, awakened minority, imbued with the idea of national liberation and impatient to achieve complete racial equality.

* * *

Our present possession and continued supremacy in the field of atomic weapons (and means of their delivery) is an important asset in that it makes the Soviet Union wary of steps which may lead to the outbreak of an open war. If, however, such a war should break out despite all deterrents, the question of using atomic weapons against Soviet (or Soviet-occupied) cities will confront America with a fateful decision, foreshadowed by our present dilemma in Korea. True, from a purely military point of view, the use of atomic weapons will be justified, since in contrast to undeveloped Korea, highly industrialized countries, such as the Soviet Union, Poland, Czechoslovakia, or Western Europe, present targets, the destruction of which promises great advantage in a war with the Soviet Union. And yet, then as now, we will be facing the same dilemma—whether to convert a fight against an aggressive and tyrannical political system into a war of annihilation against the peoples dominated by this system (whether for thirty years, as in Russia, or for three years, as in Czechoslovakia, makes no fundamental difference), or to renounce atomic bombardment, and to seek victory by slower and more costly methods.

* * *

If we concentrate on fabrication of weapons of mass destruction, and do not balance this development by the creation of a sufficiently large, well supplied, and strategically distributed land force, we will run a double danger: We will be in danger of losing out in peripheral skirmishes with Soviet satellites, such as the Korean war; and we will have deprived ourselves of freedom of decision in the event of an open Soviet aggression against nations of the Atlantic Pact. If we have nothing but atomic bombs with which to strike back, we will obviously be forced to use these weapons—even if the enemy does not do so first, and even if our leaders have grave doubts about the political wisdom and moral justification of their use.

—E. R.

A CITIZEN'S VIEW OF OUR NATIONAL SECURITY

Jerrold R. Zacharias

Criticism of American military policy, particularly of its reliance on atomic weapons, was recently voiced by a group of professors from Harvard and Massachusetts Institute of Technology in a letter published in the "New York Times" on April 30. In the following article, Dr. Zacharias, one of the signers of this letter, enlarges upon the arguments of this group.

SINCE I am a physicist, my competence to discuss military matters may be questioned. What I am going to say requires no inside track, no specialized knowledge. I believe that the basic plan of our military position can be perceived and understood without any information now secret. I should like first to consider the military positions of the United States and of Russia, as they relate to each other, and see what might happen if we continue to pursue our present policy.

IMPLICATIONS OF OUR PRESENT MILITARY POSITION

Russia has huge land armies, well indoctrinated in the methods of tactical air support and well supplied with mechanized armament. They have the important beginnings of strategic air power and of an underwater navy of the modern Schnorkel type. These services are at present probably small in number and perhaps even inexperienced, but that does not matter in the long run. They can become larger and more experienced as time goes on. We take comfort in the belief that their economic and industrial support is, in all likelihood, small. But, it must be admitted that their industrial and scientific potential is great enough, in spite of the burden of maintaining a large land army, to have produced an atomic explosion and necessarily the beginnings of an atomic bomb stockpile.

Based on an address given before the Philadelphia Bulletin Forum, on March 22, 1950.

Our own situation is almost exactly the opposite. Having atomic bombs, we have placed our major emphasis on these atomic weapons and on strategic bombing. We even plan to do more of this—to make hydrogen bombs. We are at present pitifully weak in our ground army and modern tactical air support for it. An underwater navy is not of major utility to us, since the Russians have little shipping to attack, and few major coastal industrial centers. A surface, submarine-hunting navy, on the other hand, is of prime importance to protect our coasts and to keep open our routes to Western Europe. And this branch of our navy is apparently not very large at the present time. Our economic and industrial backstop is tremendous. We have huge reserves of fat and muscle that we can cut into when we know that we have to.

U.S. DEFENSE PLAN UNBALANCED

In the light of our requirements, I believe that the present defense plan of the United States is out of balance —out of balance to the point of being dangerously impractical. It relies much too heavily on strategic warfare fought with atomic weapons, and neglects tactical defense power based on conventional weapons. It is not hard to understand why the tempting concept of strategic atomic warfare has given comfort to the American public. In the first place, when our present military policy was set, a stupendous weapon—the atom bomb—which deserves every bit of the impressive reputation it has—was our property and no one else's. It was virtually our sole source of military strength. This being so, it appeared to be a source of military security which was cheap both in money and military personnel. It fitted in with the natural and understandable reluctance of the American public to form and support a large army.

It is now clear that the United States is much more vulnerable to atomic bombs than is the USSR. Our industrial concentration and our centers of population are easier to destroy with nuclear weapons than anything of comparable importance in Russia. We have invented a weapon to which we are more vulnerable than the Russians.

MORALITY OF USE OF ATOMIC WEAPONS

I would like to digress for a moment to mention an academic subject—the morality of using atomic weapons. It is not entirely clear to me that the use of any weapon is more or less moral than the use of any other, but I know that this is a complicated and difficult question and that opinion among thoughful men has been sharply divided. One aspect of the question does seem clear to me. I think it is hypocritical for us suddenly to become great moralists because it now becomes expedient to do so. The same moral considerations existed when we used two atomic bombs in Japan, as exist now. Now that we know that Russia has atomic weapons that could be used against us, it is unbecoming to express a strong moral position since it works in our favor. Whether we were justified or not in

using those bombs, we have, I think, forfeited the privilege and the strength of a strong moral position. I turn my attention instead to matters of expediency—which are at least more clear cut than are questions of morality. With the situation as it now stands, what are our possible choices of action?

PREVENTIVE WAR OUT OF THE QUESTION

Let me first touch on the repulsive idea of what I bluntly call "War Now." Some call it preventive war; some call it prophylactic war. I contend that one need use no argument of morality, but only that of expediency, to demonstrate that it is out of the question. To be sure, if the USSR were neutralized now, before it has nuclear weapons in any quantity, I would feel a lot more comfortable about living on the East Coast. But it must be remembered that Russia holds Western Europe as hostage, and that, if we start anything, we will surely lose our friends across the sea, that Russia would proceed swiftly up to the Atlantic Ocean. I feel there is not the slightest chance that we would create such a situation.

WHY BALANCED MILITARY STRENGTH IS NECESSARY

We must, therefore, discuss a more probable course of events. What we all hope for is that the nations of the world, including the USSR, will eventually unite in fact as well as in word. That is ultimately the only possible way to live. The main value of any military preparation is to give us time. Time for what? It may be too impractical to say: Time to enable the people of the world to find out that they have to live together or not live at all. But time, at least, during which some aspect of this insupportable situation may change in our favor. So let me reiterate that military strength is at best a means, not an end. So now when I find myself an advocate of an expanded military force, with an expanded military budget, I am well aware of the possible dangers. Nevertheless, I think that it is necessary. We, in this country, are being dazzled by misleading economies in our military budget. We must spend our money not so much on our strategic air force, but on our ground army, our regular navy, and our tactical air force. At the same time, we must not neglect the necessity of restoring Western Europe to health by economic aid.

Let us assume that we get through the next few years without open conflict. Let us also assume that the Western European countries will stay as they are now, improving economically, and still politically more with us than with the USSR. The two great military powers are the United States and Russia; and there they are, glaring at each other from behind their stockpiles of atomic bombs, neither one willing to run the risk of war. Both countries appreciate the horror and the hopelessness of atomic war. Both sides are therefore necessarily conservative about the possibility of open hostility. Can this situation remain static? That depends. The Soviet policy is to move forward by piecemeal aggression, by taking a building here, by starting a little *putsch* there, by moving gradually and in small steps—no one of which is large enough nor serious enough to start full-scale atomic war. This can continue until the whole of Europe and Asia are Soviet satellites. And, ironically enough, the more terrible the strategic weapons are —the less likely is open warfare. And H-bombs only aggravate this situation. The Russians can be even more daring in their piecemeal movements, and we will be even more reluctant to try to stop them by starting all-out warfare. We might write sharp notes; we might increase the name-calling, and we would certainly increase the local witch-hunting, which results in mistrust and disunity among our own people. But we won't start anything if the incident looks small. The term "isolationist" has become very unpopular, and rightly so. No sensible American at the moment is willing to admit to being an isolationist. It is a term of opprobrium, like Communist or reactionary. But letting the Russians go step by step through Europe will indeed be an act of isolationism.

NECESSARY MEASURES

What can we do? I think that we have to make any gradual aggressions of the Russians more difficult, more dangerous, and more costly. We have to strengthen the kind of force that prevents a *putsch* before it happens. We have to be sure that the incentive for any local popular support of a defection from our side has not been strengthened by hunger. And, we have to convince the members of the Atlantic Pact that they are not buffer states. We must convince them that they and we are in the same boat, on the same team.

We first have to want to do it. Then there are a lot of things that we have to start simultaneously.

1. We must provide not only arms and tanks and planes, but the men to operate them. This means the draft. I do not propose that we try to build up enough of a force to hold the Russian land armies if they start a major land offensive across Western Europe. I don't think that is possible. But I want to see enough local force in Western Europe so that a major expedition by the Russians would be required if they want to make any move at all. That would mean all-out war, and they know it, and they don't want it.

2. We need to strengthen our sea lanes, our communications between ourselves and our allies, between ourselves and our boys across the seas.

3. We cannot afford to skimp on Marshall Plan aid, and we must expand it to help re-establish economic and industrial health for our allies.

In all of this I have made little mention of the influence of hydrogen bombs. All that I want to say is that I just hope and pray that the Russians never succeed in making one work. And as for us, we don't need hydrogen bombs, and we do need a lot of other things more. And let me emphasize that I say this from the position of one who wants vastly improved military strength for this country.

Bohr: For an Open World

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sibility on individuals and nations through the possibilities it gives for shaping the conditions of human life. The forceful admonition in this respect which we have received in our time cannot be left unheeded and should hardly fail to result in common understanding of the seriousness of the challenge with which our whole civilization is faced. It is on this background that unique opportunities exist today for furthering cooperation between nations toward the progress of human culture in all its aspects.

I turn to the United Nations with these considerations in the hope that they may contribute to the search for a realistic approach to the grave and urgent problems confronting humanity. The arguments presented suggest that every initiative from any side toward the removal of obstacles for free mutual information and intercourse would be of the greatest importance in breaking the present deadlock and encouraging others to take steps in the same direction. The efforts of all supporters of international cooperation, individuals as well as nations, will be needed to create in all countries the demand for an open world.

Copies of the *Open Letter to the United Nations* may be obtained from the *Bulletin* office on receipt of three cents postage.

NEWS IN BRIEF

PEACE PROPOSALS—IN AND OUT OF CONGRESS.—

On June 6, a resolution advocating a five-year world disarmament program was introduced by Senator McMahon and ten other members of Congress. It asks for diversion of funds destined for armaments into a fund for scientifically planned advance of world welfare, under the administration of the U.N. The resolution recognized that the plan cannot be put into operation without solving the problem of control and inspection to guarantee disarmament.

The formation of a "citizen committee" to support the plan has been announced. The plan was criticized as untimely by the *New York Times*, and defended in letters to the editor by Mr. McMahon and by former Secretary Ickes.

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A ban on use and manufacture of the hydrogen bomb and all other atomic weapons was called for by several church groups, including the Federal Council of the Churches of Christ in America, the 162nd General Assembly of the Presbyterian Church, and the New York East Conference of the Methodist Church.

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On June 11, sixteen educators and clergymen, including Albert Einstein and Louis Bromfield, issued, through the National Council Against Conscription, an appeal for atomic and general disarmament. The appeal said that certain American officials discourage disarmament, that in the United States there are at present economic interests with a stake in a large military budget, that there exists emotional attachment to armaments, and that a strong military influence is felt in policy-making branches of the government. The group suggested a five-point disarmament program: 1) halt in A-bomb production, and transfer of existing stockpiles to the U.N.; 2) acceptance of the Soviet proposal for the national ownership of atomic energy plants, but with an agreement blocking large-scale production of atomic materials; 3) international inspection of national atomic plants; 4) a compromise between the U.S. and the USSR on the timing of the destruction of atomic bombs and establishment of international control; and 5) abolition of all standing armies and reduction of conventional armaments at the same time when atomic weapons are destroyed.

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A plea for American and Soviet leaders to sit down at a conference table and to explore every possibility of achieving a "just and decent understanding," was made by Senator Tydings on June 18. The Senator from Maryland, who is chairman of the Senate Armed Services Committee and member of the Foreign Relations Committee, criticized the "long-distance sparring" which is now going on.

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The Appeal of the International Red Cross to all governments to forego the use of atomic and other weapons of indiscriminate destruction is reprinted on p. 223 of this issue. In a letter to the *New York Times*, Mr. Lewis Mumford, the writer, criticized the American government for indifference to this appeal.

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World-wide collection of signatures under the "Stockholm Appeal"—a Soviet-sponsored appeal to the U.N. to prohibit atomic weapons, establish international control of atomic disarmament, and declare those who would first use atomic weapons "war criminals,"[1] is under way. The Supreme Soviet of the USSR has endorsed it, and millions of people behind the "Iron Curtain" have been reported having signed it. In Europe and America, the collection of signatures has been pursued by communist-led unions and some left-wing organizations. Professor Niels Bohr, in answer to newspaper inquiry, said that he "cannot join any appeal, however well-meant it might be, which does not include the clearly expressed demand of access to information about conditions in all countries and of fully free exchange of ideas within every country and across the boundaries."

Many American commentators have pointed out that by launching this appeal, communists have achieved a considerable propaganda success, and that this is another example of the democracies leaving to the communists the initiative in a fight to win the allegiance of the masses which want peace.

SECURITY AND SECRECY.—

After the interrogation of Klaus Fuchs in England, FBI agents made several arrests in America. On May 24, a Philadelphia biochemist, Harry Gold, was charged with relaying information from Fuchs to Soviet officials. On June 15, Alfred Dean Slack, a chemist from Syracuse, New York, was charged with giving Gold a sample of a new explosive, RDX. David Greenglass was arrested on June 16 for having allegedly supplied Gold with secret information during the war, when he was assigned to Los Alamos as an Army technical sergeant.

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The AEC advisory security panel, headed by John H. Bugas[2] has now submitted its report to the AEC. It suggested that the AEC name an assistant general manager with broad powers over all security matters. The panel found in the AEC a tendency toward "excessive" classification, and also noted need for closer integration of security and intelligence activities. The AEC announced, on June 28, that the recommendations were receiving sympathetic study, but that the suggested changes could not be put into effect immediately since they required a major administrative reorganization.

AEC Commissioner Gordon Dean, in a speech on May 28, suggested "that in the interest of national security it may be wise to declassify certain scientific and technical information." The *New York Times* reported on June 4, June 15, and June 25 that the United States, Great Britain, and Canada were contemplating joint release of the "largest single collection of atomic energy data since the Smyth Report." However, according to the *Times*, this release will cover only the existing low temperature reactors, and will not acquaint industry with the current problems of the development of atomic power plants, (which are, substantially, high-temperature nuclear reactors).

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The American Civil Liberties Union has urged the AEC to relax its censorship rules so that the nation could obtain expert opinions on the H-bomb, "the most important issue confronting the nation today."

[1] *Bulletin*, V (June 1950), 166.
[2] *Bulletin*, V (February 1950), 64.

PRIVATE INDUSTRY AND ATOMIC ENERGY.—

In *Collier's* of June 17, David E. Lilienthal, retired Chairman of the AEC, urges revision of the McMahon Act, to relax government monopoly and to permit private industry to develop practical applications of atomic energy. He says that "No Soviet industrial monopoly is more completely owned by the state than is the industrial atom in free-enterprise America. . . . The AEC has tried conscientiously to adapt government monopoly to American industrial habits and traditions and capabilities. But it is an impossible assignment."

Mr. Lilienthal believes that the development of the industrial atom can provide the setting for another American miracle of industrial growth.

"We know how to take new discoveries and apply them to useful purposes. This kind of development 'know-how' is a distinctive American art. It is based largely on wide-open competition of ideas."

"In the midst of a desperate competition with the Russian system," he argues, "we have adopted a method that more nearly resembles the Russian system than it does our own."

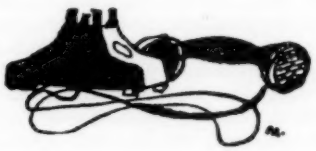
When the Atomic Energy Act was enacted in 1946, Mr. Lilienthal says, "No one could see that there was any alternative to an airtight government monopoly; certainly this was my own view at the time." However, three years of actually administering atomic energy have convinced Mr. Lilienthal that the time for revision of the Act has come. "I propose," he says, "that the basic provisions and fundamental assumptions of the Act and its administration be thoroughly re-examined by the country." He urges that the law state without equivocation, as fundamental policy of this country, that the development of the industrial atom shall be "in accord with the American system."

"If atomic energy actually were 'just another piece of military ordnance,'" Mr. Lilienthal asserts, "then government monopoly would be appropriate." But he thinks, "far more than a kind of supermunition is involved."

"The possibilities of the industrial atom appear almost limitless. We do not know," Mr. Lilienthal points out, "what chemical reactions in ordinary substances may be caused by the kind of intense radiation we now have available to us for the first time in history. We cannot be sure, today, how we can make use of the fantastically high temperatures produced by changing the heart of the atom. Will it ever be possible to produce electricity directly—that is, without a boiler and turbine and generator? It doesn't now seem in the cards. But does anyone know enough to be sure?"

Mr. Lilienthal says that when government takes over a field of knowledge, its purposes tend to become exclusive and to drive to lower and lower priority those purposes that are actually not the business of government, but of industry.

"AEC, at the very outset, launched an effort to broaden knowledge of what was at stake in the industrial atom. We tried, within the law, to increase the information and know-how at the disposal of industrial men, those outside the Inner Circle." "At the Commission's urgent invitation," Mr. Lilienthal recounts, "able industrialists gave months of their time studying this problem of making monopoly work in a land of industrial competition."



Mr. Lilienthal's conclusion is that the effort to bring a large segment of the industrial minds actively to bear on this whole new possibility has failed. "The Act's process of declassifying information having industrial value has proved unworkable." Mr. Lilienthal points out that, in fact, only one corporation in the country is making or is permitted to know how to make U-235, and only one concern is making, and only two know how to make, plutonium. "There is no intra-industry competition as to quality, price, or basic improvement in process." The estimate of costs of new power reactors are very high; they are constantly rising, by increments of millions of dollars. There is no private investment in these machines and "no financial risk to the corporations doing the work, no cost to them if estimates continue to go zooming up while completion schedules stretch out longer and longer."

"The people and corporations are good," ends Mr. Lilienthal, "but the results are not. They are not up to American par because the job is not being done the American way."

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In a commencement address at Hobart College and William Smith college in Geneva (New York) on June 10, Dr. Charles Allen Thomas, distinguished chemist, executive Vice-President of the Monsanto Chemical Company (former operator of Oak Ridge Laboratories), proposed a plan for the participation of private industry in atomic energy developments. Under this plan, industry would be allowed to design, construct, and operate atomic power plants at its own expense, to produce both useful power and plutonium. The government would lease the necessary uranium, and would receive all the produced plutonium while the company would dispose of the power. He estimated the cost of a $75,000 kilowatt power plant as about $40 million, and the operating costs as close to the 1946 estimate[3] of 0.8 cent a kilowatt hour (as compared with 0.65 cents for electric power produced from coal). A $25 million plant in Idaho mountain could be built to produce phosphorous from phosphate for profit, and deliver plutonium for the government.

INTERNATIONAL SCIENCE.—

An expansion of functions of the State Department in the field of science was recommended in a report prepared by Dr. Lloyd V. Berkner. (A summary of this report will be published in the *Bulletin* in the near future.)

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An open International Conference on Atomic Energy will be held in Britain from September 7 to 13. The meeting will assemble about two hundred atomic scientists from most Western countries, including the U.S. It was organized by the British Atomic Energy Research Establishment and will be held at Harwell and at Oxford University.

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The establishment of an International Laboratory of Nuclear Physics in Western Europe was proposed to the Unesco session in Florence on June 7 by Professor I. I. Rabi (New York), United States representative. Such a research center could be developed around a large cyclotron, and could be expected to cost in excess of $3,000,000. Dr. Rabi suggested that Unesco should act as a "catalytic agent" in obtaining the collaboration of scientists from various countries, and that it would not need to contribute to the cost of building or maintenance out of its regular budget.

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Professor Jean Thibaud, Lyon, prominent French physicist, urged pooling of Western European atomic research in the manner of the "Schuman plan" for pooling coal and iron industries, and suggested that the Marshall Plan funds be solicited to start the organization.

[3] *Bulletin*, II (September 1, 1946), 17.

URANIUM SOURCES.—

According to a speech by Dr. R. J. Wright, an AEC geologist, on June 14, the only new large-scale high-grade uranium ore separations since the war (outside the USSR dominated areas) are those in some parts of Canada, particularly near Lake Athabaska.

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According to the *New York Times* dispatch of June 18, extraction of uranium from gold ores of the Witwatersrand (South Africa) has reached pilot plant stage. This source is abundant (accumulated residues from gold extraction), but low in uranium content.

(The exploitation of low-grade secondary uranium sources of the Colorado plateau in U.S. and the discovery of primary uranium mineral veins in deep mines, such as that at Marysville, Utah, was described in the June issue of the *Bulletin*, page 177.)

MISCELLANEOUS QUOTES.—

Senator McMahon (Chairman of the Joint Committee on Atomic Energy): "Less than one-fortieth of our total military spending since the recent war has been devoted to atomic weapons; less than 1 per cent of our total national budget. To be on the safe side the scale of our atomic program should be increased."

M. Rubinstein (in the Moscow foreign language magazine, *New Times*): "At a University of Chicago Round Table Conference on the hydrogen bomb[4] at the end of February, the expenditure of billions of dollars for 'defense measures' was urged, particularly for the 'dispersal of the population of coastal cities'. The size of the expenditures recommended is truly fantastic—$25 billion a year for a minimum of ten years! Such are the appetites of the American monopolies."

AEC AND CONGRESS.—

On June 28, the Senate members of the Joint Congressional Committee on Atomic Energy recommended against Senate confirmation of Sumner T. Pike to a four-year term on the AEC. Senator Edwin C. Johnson, Democrat of Colorado, cast the decisive vote in a 5 to 4 decision which otherwise went along party lines.

The reasons for the rejection of Mr. Pike were not made public by the Senators who voted against his confirmation. The *New York Times* reported that "sources close to the committee credit some of its coolness toward Mr. Pike to the speeches he made last summer at the height of the bitterness engendered by the investigation of Mr. Lilienthal." (In these speeches, Mr. Pike was outspokenly critical of the Joint Committee.) It was also suggested that the two Senators from Colorado, Millikan and Johnson (who are both members of the Joint Committee) were dissatisfied with the AEC refusal to increase the price of uranium ore. One further recalls the rather bitter controversy between Mr. Pike and the majority of the Joint Committee over the natural gas pipe line to Oak Ridge, a project which was opposed by coal, industry, labor, and railroad interests.

Another rumor was that the opposition to Mr. Pike was caused by his reluctance to proceed with the development of the hydrogen bomb. Mr. Pike revealed in this connection, that he and the other three AEC members had written individual memoranda to President Truman on the subject of the H-bomb, and that he has pointed out in his memorandum that in contrast to the investment in the production of fissionable material, which could ultimately serve for either military or industrial power applications, the investment in the production of hydrogen promises none but military benefits. He denied, however, having opposed the building of the H-bomb for moral reasons.

After the vote on Mr. Pike was taken, Senator McMahon announced that the nominations would reach the Senate floor July 5. Considerable support for Mr. Pike, a Republican from Maine, was expected to come from the Republican senators from the Northeast. On July 10, after a postponement of five days, the Senate, by a vote of 55 to 24, confirmed Sumner Pike's re-appointment for a four-year term.

There was no opposition in Committee to the confirmation of Gordon Dean of California for three years, Thomas E. Murray of New York for two years, and Henry D. Smyth of New Jersey for one year. These new terms began on July 1, 1950, and on July 11, President Truman named Gordon Dean as Chairman of the AEC.

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Despite protests of the AEC and of the members of the Joint Congressional Committee on Atomic Energy, the House of Representatives voted to cut in half the fees paid now to the contractors who manage the AEC cities: $180,000 a year to the Roane-Anderson Company for the management of Oak Ridge, and $154,000 to the Zia Corporation for the management of Los Alamos. (The General Electric Company administers the town of Richland as part of its contract for the operation of the Hanford plutonium plants, for which it receives a nominal $1 fee.)

The AEC granted that these cities are costing the government more than they should, but argued that the contractors will not accept less and that direct government operation would be more expensive. It warned that the abrogation of existing, legally valid contracts will jeopardize the AEC's efforts to induce private firms to enter the atomic energy program. The House action still needs confirmation by the Senate.

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The Christian Response to the Atomic Crisis. By EDWARD LEROY LONG, JR. Philadelphia: Westminster Press, 1950. Pp. 112. $2.00.

La Condition Humaine et L'Atomique. By MARCEL DUBOIS. Paris, France: Pierre Clairac, 1948. Pp. 104.

Cosmical Electrodynamics. By H. ALFVEN. New York: Oxford University Press, 1950. Pp. 237. $5.00.

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[4] This round table was reprinted in the *Bulletin* in April 1950, page 106.

RED CROSS APPEAL TO GOVERNMENTS FOR PROHIBITION OF ATOMIC WEAPONS

The following appeal was made by the International Committee of the Red Cross on April 5, 1950, to the High Contracting Parties to the Geneva Conventions for the Protection of Victims of War, and, subsequently, was submitted to Mr. Trygve Lie, Secretary-General of the United Nations.

ON AUGUST 6, 1945, when the first atomic bomb exploded, the world at first regarded it as merely a means to end the war. Yet, when the devastating nature of the weapon became known, the conscience of mankind was aroused. Since then, the civilized world has hoped unceasingly that the rules of law protecting the human person against such means of destruction would be reaffirmed and supplemented. Not only has this hope been disappointed, but there is already talk of even more destructive devices. The scientists admit that whole towns could be wiped out in an instant and all life extinguished over wide areas for years. Mankind is living in fear.

The regulation of the law of war is a matter for the powers. The International Committee of the Red Cross is not unaware of that. It realizes that such regulation raises political and military questions, matters from which the Red Cross, by its very nature, must remain aloof. Nevertheless, on the morrow of the solemn signing of the four Geneva Conventions for the Protection of Victims of War, it feels bound to express its anxieties to the governments.

The desire to protect the human person against mass destruction flows directly from the principle that gave birth to the Red Cross: the individual who does not take part in the fighting or who is disabled must be respected and protected.

The International Committee of the Red Cross has not just recently come to be preoccupied with this question. On September 5, 1945, barely a month after the explosion of the first atomic bomb, it drew the attention of the national Red Cross Societies to the serious problems raised by the use of the new weapon. The representations it then made were merely the logical consequence of the attitude previously adopted by the International Committee of the Red Cross to the development of means of war. As far back as in 1918, it had undertaken to collect documentary material concerning the protection of civilian populations from aerial warfare. In this respect, it may be held to have initiated passive protection from air attack. At the same time, it had endeavored to obtain assurances from the powers that they would refrain from bombarding any non-military objectives. Accordingly, it had submitted to one of the first Assemblies of the League of Nations a series of suggestions to outlaw in the future certain fighting methods introduced during the 1914-1918 war. On the basis of conclusions by experts, it had later made an appeal to the Disarmament Conference urging the absolute prohibition of air bombardment; this appeal was supported by the documentary material collected by the Committee.

During the Second World War, it made several appeals to the belligerents, requesting them to restrict bombardments to military objectives alone and to spare the civilian population. The most important of these appeals, made on March 12, 1940, urged the governments to conclude agreements confirming the recognized immunity of the civilian population and prohibiting any aggression against it. Lastly, the International Committee of the Red Cross advocated on several occasions that security districts and zones should be established. But these representations were in vain.

RED CROSS RESOLUTION AT STOCKHOLM, 1948

When the war was over, the International Committee of the Red Cross did not abandon its efforts. And the preliminary conference of the national Red Cross Societies which met at Geneva in 1946 adopted a resolution recommending, *inter alia*, the prohibition of the use of atomic energy for warlike purposes. With the backing of that text, the International Committee submitted to the Seventeenth International Conference of the Red Cross, at Stockholm in 1948, a report referring to the foregoing, and proposed that the 1946 resolution should be confirmed and extended to cover all so-called blind weapons. The Conference passed the following resolution:

"The Seventeenth International Conference of the Red Cross,

"Considering that, during the Second World War, the belligerents respected the ban on the recourse to poisonous, toxic, and similar gases and on the recourse to bacteriological warfare, which ban had been formally proclaimed in the Geneva Protocol of June 17, 1925,

"Noting that the use of blind weapons, that is, weapons that cannot be aimed with precision or which cause indiscriminate destruction over vast areas, would mean the annihilation of human persons and values which it is the duty of the Red Cross to defend, and would jeopardize the very future of civilization,

"Adjures the Powers solemnly to undertake to outlaw absolutely all recourse to such weapons and the use, for warlike purposes, of atomic energy or any other similar forces."

Almost at the same time, the International Congress on Military Medicine and Pharmacy, also meeting at Stockholm, adopted a similar resolution.

NEW APPEAL FOR INTERNATIONAL AGREEMENT PROHIBITING ATOMIC BOMBARDMENT

Today, in reminding governments of the resolution of the Seventeenth International Conference of the Red Cross, the International Committee is faced by a situation of the utmost gravity. Up to the Second World War, it was still possible to a certain extent to take precautions against the growing destructive power of the armaments of war. It used to be possible to grant a certain protection to those who, being under international law safeguarded from warlike attack, were being more and more frequently struck down along with the combatants as a result of the power of these weapons. But no protection is possible within the range of action of the atomic bomb. And its use

is less a development of warfare than the recognition of a new conception of war which manifested itself with the first mass bombings and then with rocket bombs. However much war is to be condemned and however much it was, in fact, condemned by many treaties, war was still subject to a certain number of restrictive rules. It implied above all a distinction between combatants and non-combatants. With atomic bombs and blind weapons, a distinction is no longer possible. How can such weapons spare hospitals, prisoner-of-war camps, or the civilian population? They lead purely and simply to extermination. Moreover, the atomic bomb causes its victims sufferings out of all proportion with the tactical necessities, since many of them perish from their burns after weeks of agony or remain stricken for life with distressing infirmities. And owing to its immediate and lasting effects, no help can reach the victims.

In these circumstances, the mere contemplation of the use of the atomic bomb for whatever purpose would undermine any attempt to protect non-combatants on the strength of juridical texts. All customary rules and contractual arrangements would be in vain against the total destruction produced by this weapon. The International Committee of the Red Cross, which is particularly watchful of the fate of the Conventions for the Protection of Victims of War, has to state that the very bases of its duty would be destroyed if it were to be admitted that deliberate attacks could be made on the very people who are ostensibly to be protected.

The International Committee of the Red Cross now requests the governments which have just signed the Geneva Conventions of 1949, to do everything in their power, as a natural complement to these Conventions—as well as to the Geneva Protocol of 1925—to reach agreement on the prohibition of the atomic bomb and blind weapons generally. The International Committee of the Red Cross is bound, we repeat, to eschew all political and military considerations. But if its assistance, in a strictly humanitarian capacity, can contribute to solving the problem, it affirms its readiness to address itself to the task in conformity with the principles of the Red Cross.

For the International
Committee of the Red Cross:
LEOPOLD BOISSIER
Vice-President,
Chairman of the Legal Committee
PAUL RUEGGER,
President

Polanyi: Freedom in Science

(Continued from page 198)

Union. If we speak of the freedom of the individual to pursue his own ideas we are charged with hypocrisy. Our critics point out that we do not grant such freedom to scientists in industry or government offices, and a good deal of confusion is spread into our camp in consequence. The obvious fact of the matter is that any research which is conducted explicitly for a purpose other than the advancement of knowledge, must be guided ultimately by the authorities responsible for that outside purpose. Such external purposes are usually practical, like the waging of war, or the improvement of some public service, like telephones or roads, or simply the earning of profits for an industrial firm. If the research worker is to serve any of these purposes, he must submit his own contribution to the judgment of those who are ultimately responsible for waging war, running the telephone system, building roads, or making profits for a commercial enterprise. He must accept their decision as to what is required of him for these purposes. The degree of subordination essential to the success of applied science may vary a great deal. But broadly speaking, you must choose between dedication to the advancement of a system of knowledge which requires freedom, or the pursuit of applied science which involves subordination.

Only the more searching definition of intellectual freedom accounts for the fact that such freedom has become truly incomprehensible to the consistent followers of Marxism in Russia. The conviction which sustains them and justifies all the claims of their regime is the passionate denial of all transcendent realities. They will not recognize science as a system of truth—partly revealed and largely still hidden—which is there whether we like it or not. To them science is an ideology arising in response to social needs. And all science is class science. Marxists know that the claims of universality and freedom made by Western science rest on metaphysical beliefs which Marxists must destroy or perish. That is why they deliver themselves into the hands of Lysenkos who appeal to their fundamental tenets. I urge that we should see as clearly as they do what is at stake here and declare at last openly the beliefs which we hold and are prepared to defend.

Ridenour: Radioactive Poisons in Warfare

(Continued from page 202)

square meter a monthly area of 125 square kilometers, or about 48 square miles. Thirring's estimate for 1960 of 36 million atomic kilowatts, then, corresponds to a monthly capability of contamination of 4,500 square kilometers, or 1,720 square miles.

The three million kilowatts of atomic power that we taxpayers now have working for us in the State of Washington produce each month enough fission products to contaminate 144 square miles; the area of the Borough of Manhattan is just over 22 square miles.

Thirring mentions almost nothing about the practical difficulties of separating fission products, processing them for wartime use, and delivering them. He does suggest that, when they are separated, a water solution of their salts should be dried onto prepared sand or metal powder, the particles of the latter being chosen of the size wanted. He estimates that one-half of 1 per cent of the weight of the finished contaminated sand should be active fission products; this yields a specific activity of a million curies for every 6 kilograms of "death sand," as he calls the mixture. He points out that the layer on the ground that would be required to give a surface activity of 2 curies per square meter would weigh only 12 milligrams per square meter and would be quite invisible.

He regards his "death sand" as the lightest and most transportable of all the weapons of mass destruction. This assertion is made, however, without his having paid any but the most cursory attention to the problem of delivery. The problem of weapon engineering clearly is not trivial; neither, in all likelihood, is the problem of chemical separation of the desired fission products.

What shall we conclude from all of this? The area that can be poisoned with the fission products available to us today is disappointingly small; it amounts to not more than two or three major cities per month. The problems presented by the proper use of fission products in war are very difficult. Despite these drawbacks, the novel and unique properties of the weapon may well make it useful in special situations.

All in all, the official silence on radiological warfare probably is expressive of classification, rather than disinterest.

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